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TABLE OF CONTENTS.

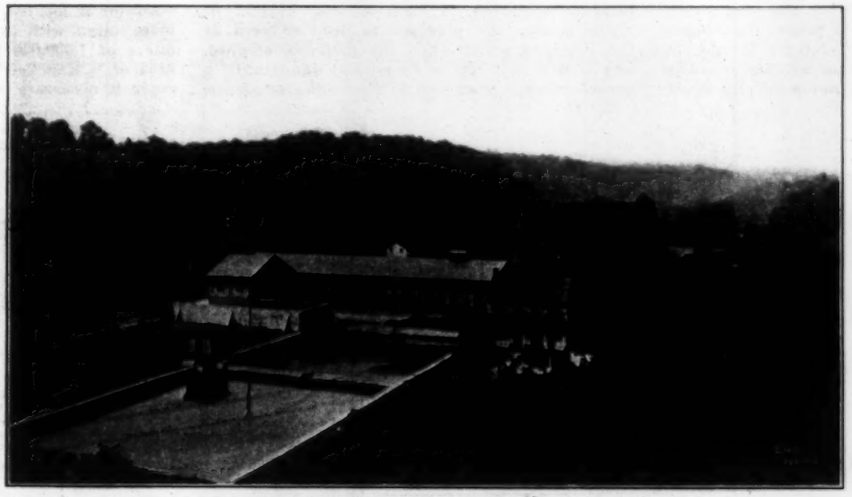
	Page.
LEADING ARTICLES:	
The Pipe Line and Purification Works and Experiments of the Baltimore County Water & Electric Co., Maryland (illustrated(; A. E. Walden	283
Pavement Construction for the Prevention of Dust and Wear; A. R. Horst	287
A Mill Building of Cement Brick Construction for the Plymouth Cordage Co. (illustrated); A. M. Bradford	288
Brick Paving and Street Railway Track Construction at Champaign, Ill. (illustrated)	290
Experiments on the Corrosion of Steel in Contact with Bronze in Sea-Water (illustrated); Edward C. Sherman, Assoc. M. Am. Soc. C. E.	292
A Study of the Corrosion of Submerged Steel in Contact with Other Metals	292
Improved Methods of Bleeding Pine Trees for Turpentine and Rosin (illustrated)	293
The Highway Work of the Wisconsin Geological Survey. W. O. Hotchkiss	294
Bascule Bridges over the East Chicago Canal (illustrated)	295
William McNab: President of the American Railway Engineering and Maintenance-of-Way Association (with portrait)	298
The Regulation of Chicago's Gas Service	298
The Ontario 110,000-Volt Power Transmission System (illustrated)	301
Operation of the Intermittent Water Filters at the Ludlow Reservoir, Springfield, Mass.	301
The Isthmian Canal; Lt.-Col. George W. Goethals, U. S. A.	303
EDITORIAL	299
The Growth of a Desire for Pure Water—Municipal Ownership of Water-Works in the Larger Cities of the Country—The Silting of the Old French Canal at Panama.	
The Canadian Import Duty on Engineers' and Architects' Drawings	299
Rapid Changes in Sewage Purification Methods as Illustrated by the Sewage Works of Sutton, England	300
LETTERS TO THE EDITOR	300
Workmen or Technical Graduates for Construction Superintendents; "Reader"—Effective Driving of Cast Concrete Piles; L. J. Hotchkiss—The Effect of Secrecy in Gas Engineering; A. S. B. Little.	
ENGINEERING NEWS OF THE WEEK	305
PERSONALS	306
ENGINEERING SOCIETIES	306

The Pipe Line and Purification Works and Experiments of the Baltimore County Water & Electric Co., Maryland.

By A. E. WALDEN.*

A number of improvements have recently been made to the water-works system of the Baltimore County Water & Electric Co., which, together with some comparative tests of slow sand and mechanical filtration and some tests of ozone, copper sulphate and hypochlorite of lime may be of interest to the readers of Engineering News. The improvements include a cross-country pipe line, 25 miles in length, and a mechanical filtration plant, both of which, as well as the tests named just above, were carried out under the direction of the writer.

The Baltimore County Water & Electric Co. supplies the greater part of the suburban territory lying north, east and west of the city of Baltimore, distributed in Relay, St. Denis, Catonsville, Arlington, Dickeyville, Tuxedo, Embla Park, Govanstown, Hamilton, Towson, Lutherville, Highlandtown, Canton and the vicinities adjacent to these, through which the pipe lines pass.



GENERAL VIEW OF AVALON PUMPING AND SLOW SAND AND MECHANICAL FILTRATION PLANT OF THE BALTIMORE COUNTY WATER AND ELECTRIC CO., MARYLAND.

The water mains at Highlandtown and Canton are supplied with water taken from Herring Run Stream, water being impounded in a 30,000,000-gal. reservoir for sedimentation. Towson and Lutherville are at present supplied from deep wells, while the balance of the territory is supplied by water taken from the Rockburn Branch, a stream which has its source in Howard County, Md., and is brought across the Patapsco River, through a pipe line to the filter plant, where it flows to slow sand filters by gravity, and is pumped to the mechanical filters by means of a submerged centrifugal pump. After being filtered, it is pumped to the storage reservoir at Catonsville, at an elevation of 524 ft. above mean tide. The water is again taken from this reservoir and pumped in a northerly and easterly direction around Baltimore City, 25 miles, toward Highlandtown, which is provided with water as previously stated.

It may be added that the company also supplies electric current in the territory just named.

The Pipe Line.

The 25-mile pipe line was laid in 1906, to supply a rapidly-growing territory which had previously been dependent on water pumped from deep wells by means of deep-well pumps, the air-lift and a triplex pump driven by gas, gasoline and steam engines.

The wells had been steadily failing for a number of years and also indicated, by the increase and variation in chlorine and alkalinity, that a change would have to be made to some supply that could be more readily controlled, both as to the quantity and bacterial content. This pipe line was put in operation Jan. 1, 1908, and consisted of some 25 miles of 12, 10 and 8-in. pipe.

Water hammer caused considerable trouble on this line, which was finally overcome by placing 14 2-in. common water relief valves at various points along the line. As the pressure in this line varies from 135 to 250 lbs. per sq. in., due to the contour of the country, it will be seen that it presented a somewhat complex problem to solve, both as to the location and pressure setting of the valves.

In testing the line before placing it in operation, the valve at the far end was closed and the pump started, and with no pressure at the pipe line entrance, the line being, however, full of water allowed to run in by gravity, it required two to four hours' pumping before there was any indication of pressure on the gages. This was accounted for by the air and the leaks in the line, and to a certain extent by the compressibility of the water in a line of such length. It may be added that no trouble has been encountered at any time due to air pockets, though the conditions were particularly favorable for the formation of such pockets.

The test pressure was gradually raised in this manner to about 20% above the required working pressure and maintained until it indicated by bursting all defective pipe and specials that had not been located in laying. This refers especially to pipe with thin places in the walls and dross that could not be otherwise detected. It also disclosed the fact that the relief valves should be placed not only at the lowest points, where the pressure was highest, but at medium high points between the pumping plant, reservoir and stand-pipe, these points being located by means of pressure gages.

After the line was thoroughly tested, the pressure was increased to that which it was intended to carry, test made, and relief valves set for pressure and placed accordingly, and so far the line has been in successful continuous operation.

This line and territory is supplied from an 8,000,000-gal. storage reservoir at Catonsville, the water being taken from the reservoir by means of an 800,000-gal. Stilwell-Bierce Smith-Vaile pump, operated by a 40-HP. Wagner single-phase motor in connection with a Morse chain drive. The motor is started automatically by a Mason belt shifter, re-designed especially to throw an oil switch from the off position to

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half taps on transformers at 110 volts and then to full potential of 220 volts on the running position. This switch was designed by the company, as it was impossible to secure anything similar or suitable in the open market. The starting device was also a special feature, inasmuch as the elevation of the base of the pump and the base of the stand-pipe, 20 and more miles away, were at the same elevation.

This device, which was also supplied by the Mason Regulator Co., is shown by Fig. 2.

The Mason horizontal switch-controlling device consists of a balancing diaphragm, against which the pressure is applied in the line between the Catonsville pumping station and the stand-pipe at Towson, some 20 miles distant. This pressure is balanced by placing weights on the beam in such a manner that when the pressure is down the weight on the beam is automatically increased by the position of the bell crank, which places additional weights on the beam to offset the friction pressure in the line. The weights cannot be moved again until the water in the stand-pipe reaches a determined level, which, added to the pipe-line friction pressure, overcomes that due to the combined weights. Then the beam rises, operating the pilot valve, which supplies water to the piston, and opens the switch. This operation requires 15 seconds or less. At the same time the weights or poises on the end of the beam are automatically lifted, the beam weight being set to equal pressure, due to the weight and height of water in the stand-pipe 20 miles distant. The pressure due to pipe line friction does not enter into this, the base of the pump and base of the stand-pipe being at approximately the same level, but separated by the above distance.

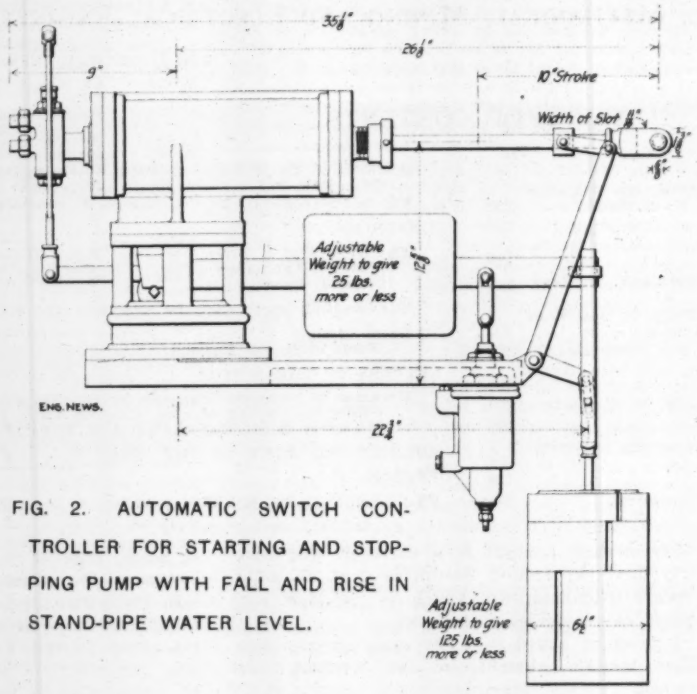


FIG. 2. AUTOMATIC SWITCH CONTROLLER FOR STARTING AND STOPPING PUMP WITH FALL AND RISE IN STAND-PIPE WATER LEVEL.

The dash pot, or time-limit device, serves the purpose of holding the beam up, after it goes up, for a period of seven minutes, as the momentum imparted to such a long column of water causes the pressure to drop to zero at the pumping plant when the pump is stopped, and it does not return to normal again until a period varying from two to four minutes passes, when it gradually returns. If this device, the pump would sta and keep starting and stoppin open all the relief valves and pipe to overflow, and perhaps d This action was foreseen befo placed in operation, but it w make a design for a movem magnitude at the time, and pro tingencies, until after the appara in operation.

The pressure in the line at pump standing idle, would be elevation of the water in the sta was desired to start the pump had fallen 5 ft. in a 60-ft. stan the pump out when the stand-pi 2 ft. of being full. It was nece a device that would start at fro and cut out at 80 to 100 lbs., at not go into operation again until had fallen below 25 lbs., the diffe pressure of 75 lbs. being that du These pressures are approximate, with the demand.

The building in which this installation is located is a brick and concrete fireproof structure, electrically heated and lighted from the company's mains. The pump is oiled as follows: A belt from the pump shaft drives a small rotary oil pump that takes its supply of oil from one tank and elevates it to another, from which it flows by gravity back to the main tank to be pumped over again. The oil supply to the pump is taken from the elevated line to the second tank at a point that gives a suitable pressure to the sight oilers on the pump. In this manner the oil starts when the pump starts, and stops when it stops.

The Mechanical Filter Plant.

The company had been supplying, for four or five years, the district in which the above-named reservoir is located, and which is west of Baltimore city, with water filtered by slow sand filters of 1,500,000 gals. capacity and a ground area of ½ acre (see Fig. 1). The new extension made it necessary to install additional capacity.

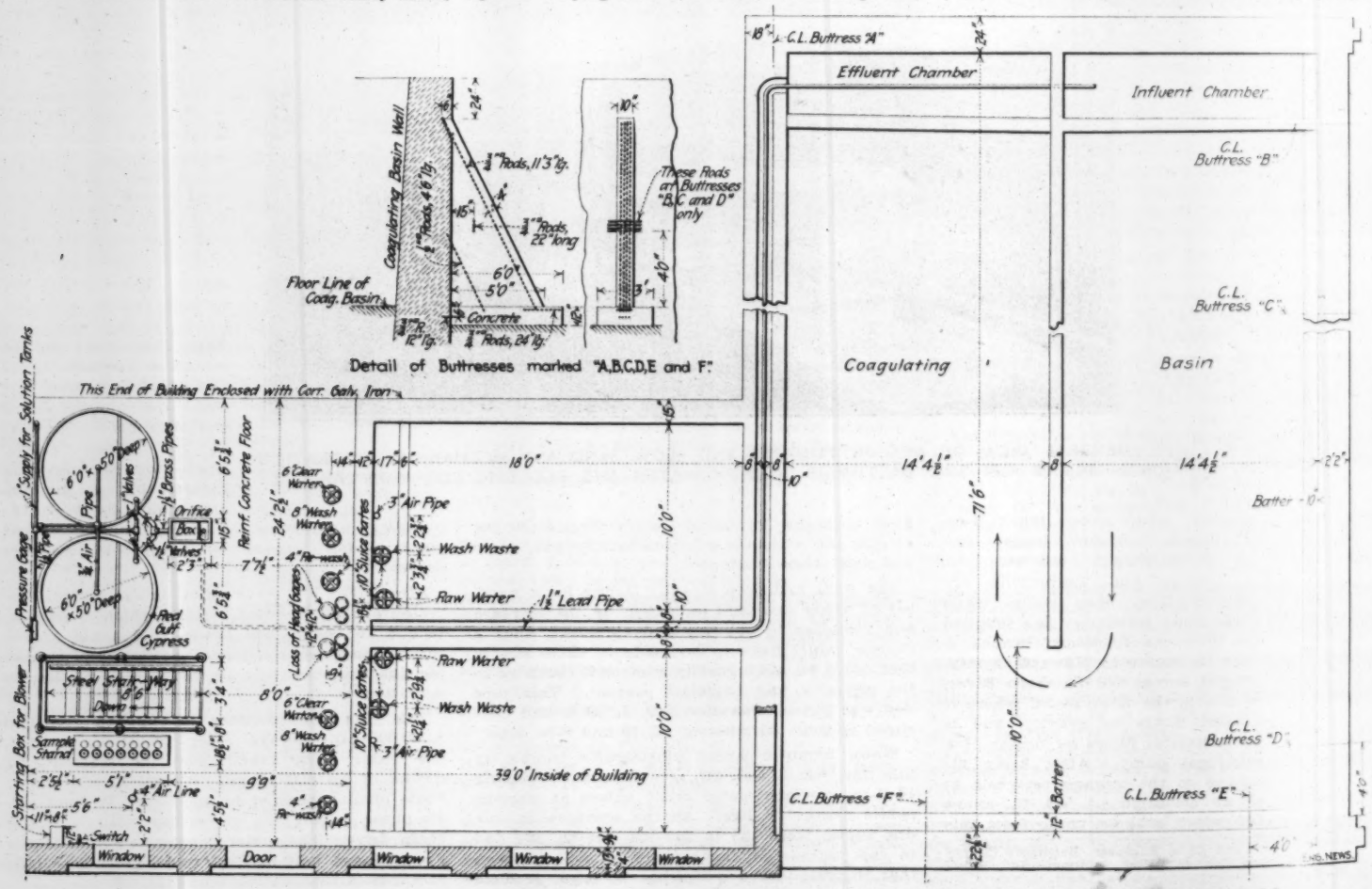


FIG. 3. GENERAL PLAN OF AVALON MECHANICAL FILTER PLANT, BALTIMORE COUNTY WATER AND ELECTRIC CO.

and it ... decided before increasing the capacity of the ...ters to investigate the merits of the mecha... or rapid system of filtration in comparis... ...h and alongside of the slow sand system. ... data could be procured with such an instal... using the same water at the same time ... under the identical conditions as to turbid... ...nd bacterial efficiency, mechanical plants ... various points were inspected. Plans were ... made by the company, which were after... modified to take equipment manufactured ... Pittsburg Filter Mfg. Co., which was given ... contract for the construction and equip... of two 500,000-gal. mechanical filter units ... description of which is here given, as well ... at of the slow sand filters, which are in two ...ts of 750,000 gals. each.

The ...hanical plant consists of two 10 × 20-ft. co... ...e tanks (Figs. 1 and 3 to 6) containing the sand, strainers, distributing pipes for the air wash, and wash-water troughs. The water is brought to these beds by means of a canal in the walls of the coagulating basin and in the concrete wall dividing the two units. This channel is also used for the coagulant line to the coagulating or sedimentation basin inlet. The sedimentation basin (Fig. 3) is designed to provide four hours' sedimentation before the water reaches the skimming wall. The plant is electrically equipped throughout. Fig. 4 shows the piping of the mechanical filters. Fig. 5 shows the loss-of-head gages.

The raw water pump which supplies the coagulating basin is a vertical centrifugal, direct-connected to a Wagner single-phase vertical motor of 15 HP., operating at 1,165 r.p.m. The raw-water levels in the pump well and basin are controlled by float valves, the level of the water in the basin also controlling the level or depth of water on the beds, or positive heads. A sample pump is driven by a three-phase 25-cycle, 2-HP. motor. The Roots blower which furnishes air for the air wash is direct connected to a 10-HP., 3-phase, 60-cycle motor, supplying 750 cu. ft. of air per min. at 3 to 6 lbs. pressure. From data obtained since the plant was installed it now appears that a 7½-HP. motor would have answered every purpose.

The laboratory equipment, heating apparatus, and incubators are all electrically heated, and hot water is supplied by means of an instantaneous electric heater. The plant is so designed that the entire operation is controlled from the operating floor. The raw-water pump, blower and sample-pump motors being located at other points, only the switching and controlling apparatus is within reach of the operator when he is operating the valves. This apparatus in close proximity to the loss-of-head-gages, wash-water and air gages, and four orifice-box controllers are within sight and easy reach.

The rate of filtration is controlled by a new type of rate controller, manufactured by the Pittsburg Filter Mfg. Co., which consists of a floating orifice or weir, which can be varied by adding to or deducting weight, and it has so far given very satisfactory service.

The wash-water supply for washing presented a problem, as the only source of filtered water was the force main, which is under 250 lbs. pressure per sq. in. An 8-in. line with an 8-in. Foster pressure-reducing valve was provided, which has so far been fairly satisfactory. It was found that the percentage of wash water could not be used to determine the amount required, as instead of a rate of 500 gals. per min., it required 500 gals. or over in 15 secs. or less, and satisfactory washing could not be accomplished with the sand in perfect suspension, with a rise of less than 12 ins. per min. through the beds. This result depends not only on the number of gallons, but more on the velocity at which the water flows through the beds, and it was found that an air pressure of 3 lbs. would give ample agitation for satisfactory washing.

The sample table supplied by the sample pump is designed to show immediately any change in the operating conditions by means of glass cylinders connected with the raw-water inlet, coagulating basin, clear well and each unit of both the mechanical and the slow sand filters. The plant is so designed that it is fireproof and that extensions can be made at very slight cost as compared with the first installation.

The slow sand filter plant is in two beds, each 78 × 115 × 8½ ft. deep, into which the raw water flows by gravity. The rate of filtration is governed by floating controllers in separate chambers, which carry an orifice that can be increased or decreased by adding or removing weights to or from the floats. The height of the water in these basins is controlled by float valves in separate chambers, opposite the float chambers, in which are located the raw-water controllers for controlling the head of raw water in the pump well of the mechanical filters. The depth of the sand and gravel on these beds was originally 51 ins. The underdrains consist of split tile, laid on a concrete bottom and connected to lateral drains in the usual manner.

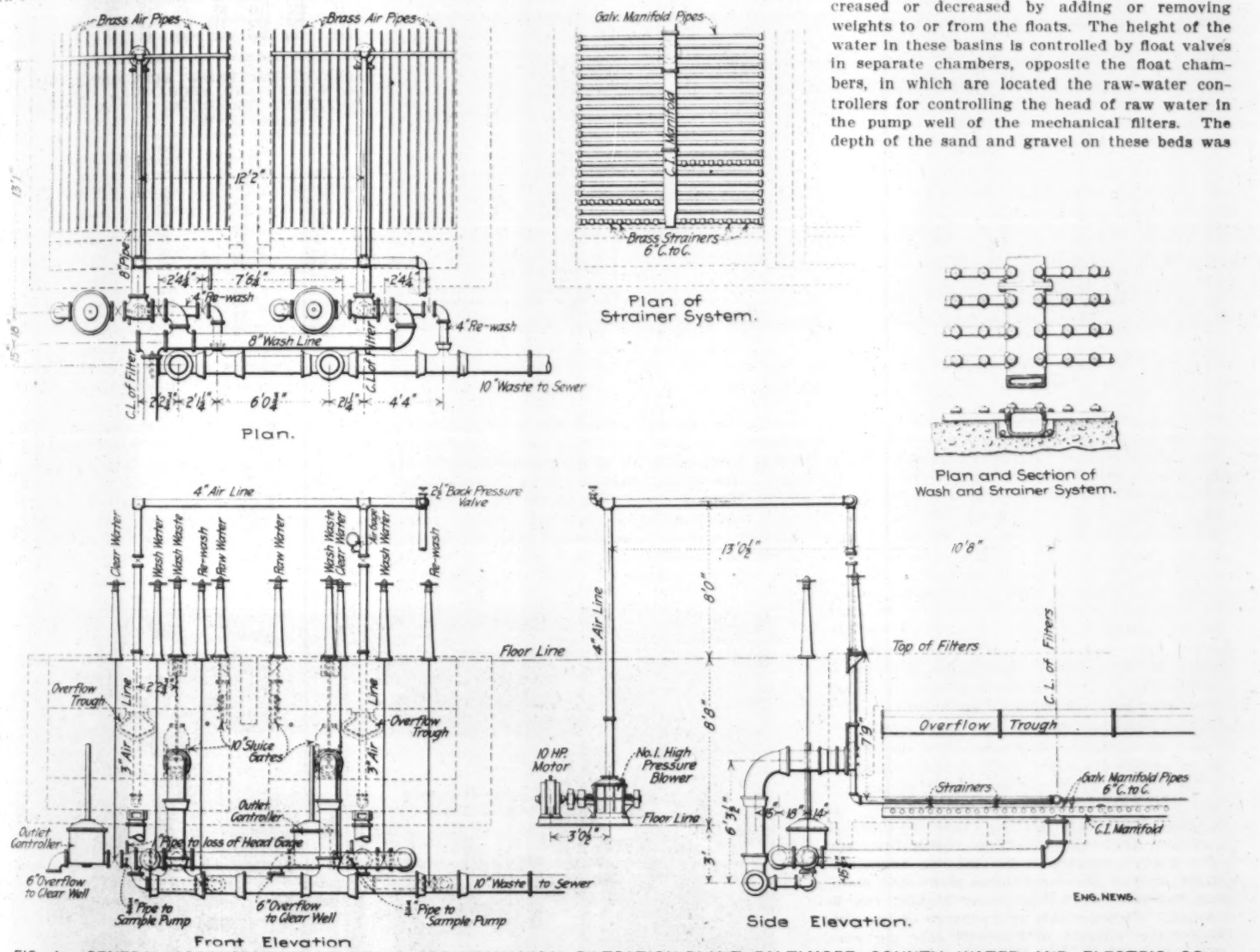


FIG. 4. GENERAL ARRANGEMENT OF PIPING FOR MECHANICAL FILTRATION PLANT, BALTIMORE COUNTY WATER AND ELECTRIC CO.

Comparative Results with Mechanical and Slow Sand Filters.

The operating results so far indicate that the mechanical filtration plant is cheapest to install and is more easily handled where the turbidity is subject to sudden fluctuations, but that it needs more careful watching, for if the high turbidity reaches the beds without sufficient alum for coagulation having been added immediately the turbidity will appear in the effluent in 20 minutes. Even if alum in large quantities is admitted immediately, yet at times it does not act quickly enough.

With the raw water showing a turbidity of 5,000 on the silica scale, the slow sand filters, after they had been in use about three weeks, ran four hours before breaking down. Even

then the filters held the turbidity in the clear well at 50, indicating that with proper sedimentation and with coagulation only sufficient to form a blanket on the beds the plant could be operated under almost any condition of turbidity with the operating cost less than that for the mechanical plant.

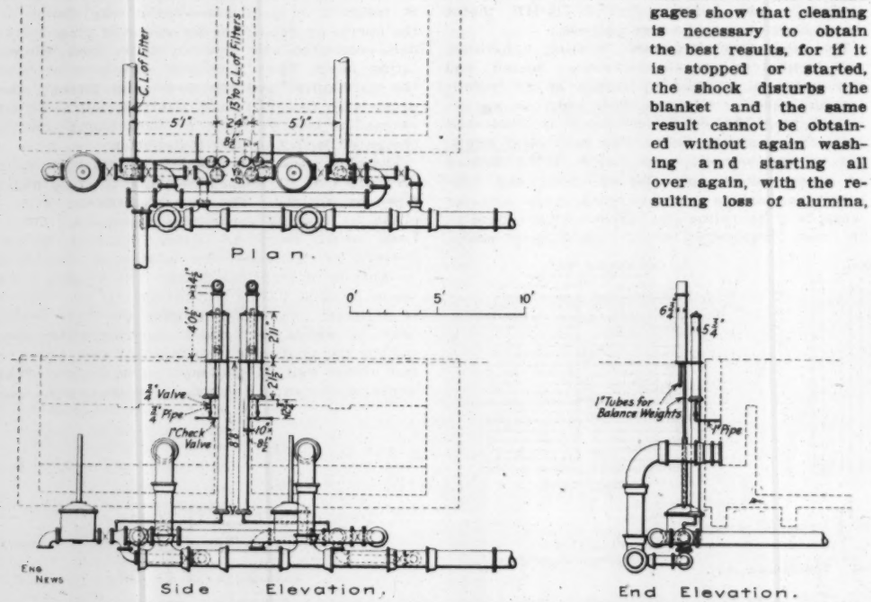


FIG. 5. LOSS-OF-HEAD GAGES FOR MECHANICAL FILTERS, BALTIMORE COUNTY WATER AND ELECTRIC CO.

The water treated is brought across the Patapsco River from Howard County, where the raw water is collected by means of a small concrete dam across Rockburn Branch, but in time it will be necessary to use the Patapsco River water itself, and it is a much easier water to handle, as the turbidity is higher.

The bacterial results so far obtained indicate that the slow sand filters will reduce the number of bacteria in raw water having a low turbidity and count below that of the mechanical filters, but that high turbidity (not in excess of 1,000) and with high bacterial counts the reductions are about the same for each type of filter. Table I. illustrates this.

As the turbidity increases, the mechanical filters reduce the count until it runs below that of the slow sand filters for a short period, and then rises until they are both reducing the count in about the same proportion, but as the turbidity decreases, the slow sand filters reduce the count until it runs about half that of the mechanical filters, though the mechanical plant will maintain the low count if a proper blanket can be formed. With the rate of discharge of the slow sand filters reduced to 1,000,000 gals. per acre, the counts in the effluent or filtered water have been reduced to 3 per c.c., eight days of cultivation being required to get this number. Each plant, however, has turned out an effluent containing from 1 to 2 bacteria per c.c., or practically a sterile water. Tables I. and II. will show how the results run on the two plants, also the count after washing the mechanical filters.

The slow sand filters have come into operation in four hours after cleaning, reducing the count to about 40, or giving about 95 to 96% efficiency. Need of cleaning is indicated by the uniform increase of bacteria in the effluent and by the increase of positive head on the beds.

The comparative efficiency of the two systems seems to depend on the character and treatment of the raw water. It will be noticed how the results obtained by the two plants cross. After a careful determination of the alkalinity and experimental introduction of lime, etc., it was decided that at times the alkalinity was in some form not suitable for proper and immediate reaction with the alum. By adding clay or mud (Table III.) these conditions change immediately, and turbidity results are secured equal to those given by the slow sand filters.

The mechanical plant should be allowed to operate continuously after the blanket is formed, and until the loss-of-head gages show that cleaning is necessary to obtain the best results, for if it is stopped or started, the shock disturbs the blanket and the same result cannot be obtained without again washing and starting all over again, with the resulting loss of alumina, which amounts to considerable in the run of a year.

The pumping plant at this point consists of two 1,500,000-gal. duplex pumps furnished by R. D. Wood & Co., driven by two 36-in. McCormick wheels under 21 ft. head, and a Corliss tandem compound condensing engine, the pumps being designed for operating under 250 to 300 lbs. per sq. in. pressure. This station contains also the generators, wheels and engines for lighting and power for street and commercial purposes in this same territory.

Ozone Treatment.

An experimental ozonizing plant has recently been installed to ascertain whether satisfactory and cheaper results can be obtained by this method than by filtration.

The ozone generator consists [illegible] series of plates and discharge terminals pr[illegible] g a brush discharge when connected to the [illegible]inals of a 10,000-volt step-up transformer. [illegible]e air is passed through the generator with[illegible]rying and is thoroughly mixed with the wat[illegible]e purifying action taking place immediate[illegible]

TABLE I.—BACTERIA IN MECHANICA[illegible]LTER EF[illegible] FLUENTS AT VARIOUS PERIODS [illegible]R WASHING.

Raw water.	Bacteria per C. C. Minutes After Washing. 0	5	10	20	30	60	Coagulant, grains per gal. Ba.	Fil.
8,125	225	180	142	236	207	205	sin.	ters.
1,200	228	206	223	115	110	73	1.10	.37
675	240	305	215	135	150	70	.98	.10
340	900	390	225	152	95	82	.98	.00
20,400	2,550	725	290	500	150	135	.88	.00
18,000	240	100	50	34	75	67	.48	.78
20,400	250	100	88	15	19	26	.48	.98
15,000	185	120	11	9	14	11	.98	.74
18,000	180	160	33	52	15	16	.98	.60
							.98	.74

TABLE II.—BACTERIAL EFFICIENCIES OF THE SLOW SAND AND MECHANICAL FILTERS WITH DIFFERENT TURBIDITIES OF THE RAW WATER.

Raw Water.	Bacteria per C. C. Mech. Filters, No. 2	Slow Sand Filters, No. 4.	Turbidity of Raw Water.	Coagulant Used. Mech. Filters.
630	36	6	12	.73
980	29	8	10	.73
410	38	6	10	.73
420	32	5	8	.73
1,200	26	3	10	.98
900	23	26	30	.98
1,020	17	31	40	.98
1,150	15	30	50	.98
1,000	14	30	50	.98
860	13	25	50	.98
940	8	24	60	.98

TABLE III.—EFFECT OF ADDING CLAY OR MUD TO WATER APPLIED TO THE MECHANICAL FILTERS.

Turbidity.	Raw Water Count.	Mechanical Filter, No. 1.	Slow Sand Filter, No. 3.	Alkalinity.	Coagulant, Grains per gal.
10	570	26	11	19	.98
A—18	3,100	12	14	22	.98
20	980	98	15	22	1.10
A—28	3,920	40	35	20	1.10
A—30	4,480	4	12	19	1.10
8	820	87	8	22	1.10
A— 8	720	18	14	21	1.10

Counts lettered "A" show the effect of the addition of clay or mud.

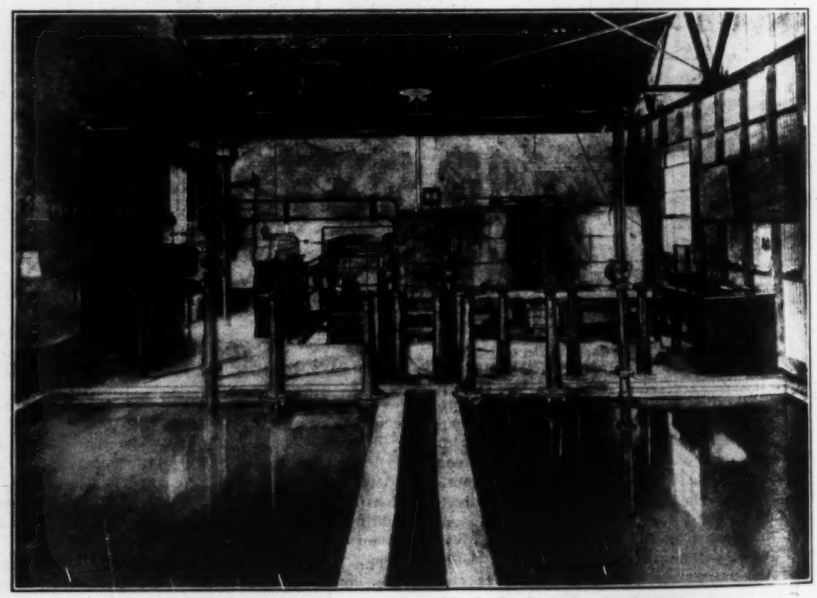


FIG. 6. OPERATING FLOOR OF THE MECHANICAL FILTER PLANT OF THE BALTIMORE COUNTY LIGHT AND WATER CO.

If the turbidity and organic matter are too high the ozone required for successful treatment is prohibitively high, as is shown by Table IV.

The system requires several improvements and refinements which will be worked out on lines indicated by the experiments so far conducted.

This company operates a low-service plant east of Baltimore City, having a total pumping capac-

TABLE IV.—EFFECT OF OZONE TREATMENT ON WATER.

Bacteria per C. C.		Coli.		Color.			Turbidity.			Oxygen required.*		
Raw water.	% Removed.	Raw Present	Ozonized. Not Found	Raw.	Ozonized.	% Removed.	Raw.	Ozonized.	% Removed.	Raw.	Ozonized.	% Removed.
2,400	98.95	"	" "	30	15	50.00	40	40	00.0	1.40	.85	39.19
2,800	99.58	"	" "	17	0	100.00	15	15	00.0	1.15	.55	52.18
1,100	99.55	"	" "	35	15	57.15	15	15	00.0	1.47	.85	42.18
1,270	100.00	"	" "	12	0	100.00	17	17	00.0	1.15	.70	39.13
1,200	98.85	"	" "	65	40	38.47	400	400	00.0	3.75	3.10	17.34
59,000												

*To ... the carbonaceous organic matter in the water after treatment.

ity of ...0,000 gals. and a 30,000,000-gal. storage ...oir. The experiments already outlined ...ated that raw water here might possibly ... economically handled by the ozone meth... especially if preliminary roughing filters were ... as it has been found by experiment at this ...ervoir that, with a high bacterial count, a turbi... of 2,000 and an alkalinity of 37, the introduc...on of an alum solution at the reservoir inlet ...uced the turbidity and bacteria by 99% in ...e of 20 minutes. This will vary, however, ...h the changes in the character of the water.

As a result of our experiments with ozone treatment, we have contracted with the United Water Improvement Co. and Mr. J. Howard Bridge, for the right to use the J. Howard Bridge ozonizing patents, adapting the same to plans gotten out by Wehr, Walden & Dukehart, Engineers, for the Baltimore County Water & Electric Co. The roughing filters for use with this equipment are also being designed by the engineers named, and contracts will be let for the work to local people. The special apparatus, other than the ozone generators, themselves, will be designed by Wehr, Walden & Dukehart, and Mr. J. Howard Bridge will have the oversight and supervision of the design of the ozone generators on the ground in person.

Ultimately this installation will be capable of handling 10,000,000 gals. of water daily. The installation will be along lines similar to the one in use for some months past at Lindsay, Ont., which has been visited by the writer. In working up our plans here some substantial departures from the Lindsay plant will be introduced.

Hypochlorite of Lime.

Numerous experiments have been made with hypochlorite of lime, with results as shown in Table V., the application being made in the canal, between the sedimentation basin and the mechanical filter beds. With 0.1 grain of hypochlorite of lime, and with the alum solution cut to 0.7 gr. per gal., and running the hypochlorite solution on the beds every other day, we have been turning out an absolutely sterile water; that is to say, 50% of the samples taken from the effluent of the filters contained no bacteria whatever. The balance of the plates had 1 and 2 individual bacteria and it required about six days' growth to cultivate these.

Additional experiments with the hypochlorite have practically convinced us that we can still further reduce both it and the alum and secure equally good results. We have noted that after using the hypochlorite there is a slight increase in chlorine, amounting to 0.25 to 0.5 parts per million, and that by the application of 0.1 grain of hypochlorite the bacteria have been reduced from 6,000 to 16, with one sterile plate from the effluent, and one plate having 2 bacteria. The time required to make this reduction was 40 seconds. That is to say, a sample was taken before applying the hypochlorite which showed 6,000 bacteria when applied; 40 seconds after application another sample was taken and the count reduced to 16 as shown by the plate. We attribute these results to the generation of nascent oxygen.

The use of hypochlorite of lime in this plant has reduced the amount of wash water necessary to clarify the beds, besides cutting down the alum bill. The wash-water reduction has been from 16,000 and 25,000, respectively, to 7,000 and 10,000 gals., the filters running 30 hours when hypochlorite is used as against 24 hours when alum alone is used.

Copper Sulphate.

It has been found that treating the underdrains of the slow sand filters with a copper sulphate solution will keep the bacterial growth under control; in fact, will prevent it altogether if the treatment is carefully done. After the first treatment the growth is very slight when the filters are standing idle, but comes back to normal as soon as the filters are placed in operation. Too strong a solution of copper sulphate causes a reaction which throws the sulphate down in changed form, depending on the constituents in the water. It has also been shown that copper sulphate will kill B. coli in 24 to 48 hours, if they are present in the raw water.

TABLE VI.—BACTERIAL RESULTS OBTAINED BY THE USE OF HYPOCHLORITE OF LIME.

Time of application.	Bacteria, raw water.	Grains per gallon — Bacteria, treated water — .11	.22	.33	.49	Time after application.
0	500	10	6	8	8	5 min.
0	510	13	12	6	14	10 min.
0	550	6	10	9	6	15 min.

A HIGH-PRESSURE WATER SYSTEM has recently been installed by the City of Winnipeg, Manitoba. About 7½ miles of 8, 10, 12 and 20-in. mains have been laid in the business district, and on these 78 fire hydrants have been set. Water for this system is taken from the Red River by means of a pumping plant with a total capacity of 10,800 U. S. gals. per min., or 15,552,000 gals. per 24 hrs., at a pressure of 300 lbs. per sq. in. The plant includes two 1,000-HP. and two 500-HP. gas producers with 50% overload capacity, and six 4-cycle Crossley gas engines, of which four are of 540-HP. and two 250-HP. each. These engines drive six triplex double-acting pumps made by Glenfield & Kennedy, of Kilmarnock. It is figured that, using anthracite coal at $8.50 per ton, the cost of fuel for operating this plant is at the rate of 0.425 cts. per HP. hr. The plant is being operated on bituminous slack. The highest building in Winnipeg is eleven stories. It is reported that 24 1¼-in. or 10 2-in. streams can be thrown over this building. The total cost of the high-pressure system, including the equipment already described and a brick pumping station, 92 × 158 ft. inside measurements, and a brick producer gas building, 221 × 34 ft., was about $750,000. The foundations of the pumping station are of concrete and were carried to a depth of 10 to 25 ft. The concrete work was continued through the winter of 1906-07. The station and machinery foundations were built entirely by day labor. The guaranteed duty of the pumping engines was 162,000,000 ft.-lbs. per 1,000,000 B.T.U. in the gas furnished to the engines. The results reached on the large engines were 178,877,000, 182,173,000, 174,699,000 and 178,236,000 ft.-lbs. Mr. H. N. Ruttan, M. Am. Soc. C. E., is City Engineer of Winnipeg.

Paving Construction for the Prevention of Dust and Wear.*

By A. R. HORST.†

If the speed of motor cars could be kept within the limits assigned by law very little damage would result, but there seems to be no way of doing this. The shearing, sweeping, and raveling effects of motor cars do not attain dangerous proportions up to speeds of 20 or 25 miles per hour, but above that speed the damage increases in greater ratio than the velocity.

Only good, hard and tough stone should be used in the top course of macadam, and it is often better to pay $2 for granite (for this cause) than $1.50 for limestone. But even the best stone surface will produce too much dust if left to take care of itself. Sea water and solutions of soap and of calcium chloride and other salts have been used to lay the dust, and are claimed to be cheaper than fresh water. Even the best salt solutions have to be applied frequently in hot weather, and puts their use out of the question for rural highways.

The principal dust layers are made up of oils and tars with more or less paraffine, pitch, bitumen or asphalt in their composition. Some are applied hot and others cold, some neat and others in solution. In Boston they use solutions of 8 to 15% with (it is claimed) excellent results; they maintain the road with 1½ pints per sq. yd. annually, at a cost of 2 cts. per sq. yd., which is considerably less than the former cost of sprinkling with water.

The more general way is to use the oil neat. The surface is first swept clean, depressions are filled with stone until the road surface is smooth and even, and the oil is then applied at the rate of about ⅛-gal. per sq. yd. In cool weather the oil is heated. As soon as the oil is applied, the sweepings (with additional screenings or sand) are spread over the surface and the street rolled a few times with a steam roller. The street is then opened to traffic. At Kansas City the results have been excellent, and in 1907 there was a saving of $5,500 over the amount for water sprinkling in 1906; there is also a large saving in the smaller amount of repair work, cleaning catch-basins, etc. Most of the driveways received two applications each year. The oil cost 1.8 cts. per gal., and the total cost of each application was about 1 ct. per sq. yd. Tars are applied in mud the same way, but are usually heated and are seldom used in solutions. One application per year will generally suffice, with from ⅛ to 1⅛ gals. per sq. yd. Results have varied from complete success to entire failure, and tars or oils should be tested before using. They should have a good percentage of bitumen or asphalt.

While these methods are of great assistance in suppressing the dust nuisance, they are at best palliatives and not preventatives. The problem is best attacked at the time when the road is built, and the preventative material should be incorporated in the road. A permanent binder for this purpose must be adhesive, resilient, and not subject to deterioration from frost. Tars, bitumens and asphalts fulfill these conditions and are generally used.

In some cases the stone is heated, coated with the hot binder by turning with shovels, then spread and rolled. On this is spread a wearing coat of fine material thoroughly mixed with the binder, and after rolling it is covered with dry screenings, gravel or sand. So far this has been successful in producing a pavement that is noiseless, free from dust and mud, and of good wearing qualities. The cost is high (owing to the methods), probably from $1 to $1.50 per sq. yd., which precludes its use except for roads having considerable traffic. Another method is to spread a matrix of stone and binding material upon the well rolled bottom course of stone. The second course of stone is then spread and rolled so that the matrix fills the voids. The surface is then covered with chips, screenings or sand, and finally rolled. This method has proved satisfactory. Various conditions as to size and binder are used.

An economical method in use in England consists in laying and rolling the two courses of stone in the usual way, then rolling a thin coat of stone chips, and finally filling the voids with tar at the rate of about 1/6-gal.

*Abstract of a paper read at the first meeting of the Engineering Society of Wisconsin, held at the University of Wisconsin, Madison, Wis., Feb. 24 to 26, 1909.
†Wisconsin State Geological Survey, Madison, Wis.

TABLE V.—CHEMICAL AND PHYSICAL RESULTS OBTAINED BY TREATING WATER WITH ALUM AND HYPOCHLORITE OF LIME AND (ANOTHER TEST) WITH ALUM ALONE.

Bacteria per c. c.				Alum and Hypochlorite of Lime. Grains per gallon.									
Basin, time, 40 sec.		Filter		Alum		Hypochlorite of lime.	Turbidity		Color		Alkalinity		Chlorine	
Raw water.	Before application of hypochlorite.	After application of hypochlorite.	No. 1.	No. 2.	Basin.	Filter.	Basin.	Raw.	Filter.	Raw.	Filter.	Raw.	Filter.	Raw.	Filter.
400	400	14	0	2	.96	.00	.10	15	0	12	0	16.0	8.0	3.50	4.00
550	550	10	1	..	.98	.00	.15	18	0	14	0	13.0	8.0	4.00	....
30,000	6,000	16	0	2	.98	.12	.10	200	0	30	0	17.0	7.0	3.50	4.00
2,000	1,350	8	0	0	.86	.10	.10	80	0	28	0	12.0	6.0	4.00	4.25
					Use of Alum Alone.										
	Sedimentation basin.	Sedimentation basin.													
400	210	210	8	Out	.86	.15	None used	15	0	15	0	15.0	11.0	4.00	4.00
420	330	330	9	of	.96	.00	"	15	0	12	0	12.0	6.0	4.00	4.00
500	330	330	6	ser-	.96	.00	"	12	0	12	0	12.0	5.0	3.50	3.50
370	390	390	20	vice.	.96	.00	"	12	0	10	0	10.0	2.0	4.00	4.00

per sq. yd. An extra coat of screenings (or preferably stone chips) is then applied, to absorb any excess tar, and the surface is again rolled. This has given great satisfaction, and the estimated increase in cost is only from 20 cts. to 25 cts. per sq. yd. Every few years the surface must be swept and "painted" with tar, but much less maintenance is required than under the old methods.

Liquid asphalts are used in much the same way as tar, and have been successful. Most of them are patented and are somewhat more costly than tar, but seem to give more lasting results. Certain natural rock asphalts are on the market. These take the place of the ordinary screenings and are applied dry to a depth of about 1 in. They are said to produce a surface very wear-resisting and free from dust.

The following conclusions may be drawn: Water sprinkling is the most expensive method. Oil and oil emulsion give good and cheap results where the cost of oil is not too high. Tar is excellent as a surface treatment or as a binder incorporated with the road material. Bitumens and asphalts are the most permanent binders, and the most satisfactory if the cost is not considered. The greatest possibility of success lies in the incorporation of the binder with the practically completed macadam.

For dirt roads, oil has been used to lay the dust but is now used mainly to obtain a semi-asphalt surface that is a good substitute for macadam. The oil is sprinkled at the rate of from 1 to 2 gals. per sq. yd., the surface being first stirred to a depth of 2 or 3 ins.; the oil is well mixed with the earth, forming an impervious crust. Each succeeding year requires only a small application of oil. This system has been used with success in California, and has led to the introduction of the petrolithic system, in which the oiling is carried to a depth of 6 ins. and the material then consolidated with a tamping roller. There are three sprinklings of oil, about ¾-gal. per sq. yd. for each. On this surface is laid a 2-in. bed of small stone, which is sprinkled with the same amount of oil; this is rolled, covered with ½-in. of screenings and the surface given a final rolling with an ordinary smooth roller. These roads are said to be superior to macadam; they are noiseless, dustless and easy on the horses. In California they cost from 33% to 75% of the cost for macadam. The system is not patented, but the tamping roller is a patented device.

APPROACH LOCKING OF A SWINGBRIDGE characterizes a single-track railway bridge over the Barrow River, in southern Ireland, on the line from Waterford to Rosslare Harbor. The swing span of this bridge is locked in closed position when a train is within 5½ miles of the bridge on one side, and within 3 miles on the other side. When the bridge is open it locks the railway signals at danger over the same sections of track. Judging from this arrangement, the river has not a very heavy vessel traffic.

The bridge in question, described by Mr. A. S. Biggart before the Institution of Engineers and Shipbuilders in Scotland, is a two-truss through bridge 2,131 ft. long, carrying a single track of 5 ft. 3 ins. gage (Irish standard gage). It consists of 13 140-ft. fixed spans (piers spaced 148 ft. c. to c.) and a swingspan 214 ft. 6 ins. long, giving two 80-ft. clear channels. The trusses are of Pratt type, 20 ft. deep, while the swingspan is of pure rim-bearing type. The piers are double cylinder piers, sunk by the pneumatic process, and extend to unusual depth; the bottom of the deepest is nearly 120 ft. below high water, but the air-pressure did not exceed 45 lbs. at any time. The bridge was built by Sir Wm. Arrol & Co., Ltd., and was designed by Sir B. Baker.

A Mill Building of Cement Brick Construction for the Plymouth Cordage Co.

By A. M. BRADFORD.*

In this cement age much is written on the use of Portland cement as a building material to replace brick, stone, terra-cotta and slow-burning types of construction. Plain, reinforced and hollow-block concrete construction have passed the experimental stage, and are factors of undoubted importance in the building world. As yet but little has been written upon the subject of cement brick (or concrete brick) construction. This last type is comparatively in its experimental stage, but enough is known to demonstrate beyond argument that in sections of the country where sand is plentiful, the cement brick can be made to compete with common clay brick in price and to equal face brick in appearance.

The building of which this article will treat is the No. 3 mill erected for the Plymouth Cordage Co., at North Plymouth, Mass. It is to the best knowledge and belief of the writer the largest of its type in the country. The writer had the good fortune to superintend the making of the brick, as well as the construction of the building, and is in a position to present here facts which have come under his observation, and which he trusts will contain something of value to those who are interested in or connected with the use of Portland cement as a substitute for other building materials.

The conditions which governed the construction of this plant may be explained. Two other mills of the company had been built of clay brick, but at the time the third mill was planned, in the fall of 1906, the price of clay brick was extremely high. The quality also was insufficient to withstand (without disintegration) the continued racking of gales which blow from the Atlantic. The company owned a huge bank of clean, sharp silicious sand, and a pit of gravel containing a liberal percentage of stone. It was desired to minimize outside profits. After preliminary tests on short-time set, it was decided to use cement brick.

The organization of the working force was as follows: The entire field of operation was under the general supervision of Mr. Geo. W. Bradford, whose word was final in all questions of construction or conduct of the work, the company giving him a free hand. Under him there were Mr. N. S. Holmes as superintendent of the carpenter work, and the writer as superintendent of excavations, foundations, brick making and brick laying. Carpenters were hired by Mr. Holmes. Masons, tenders, laborers for concrete and brick making, were hired by the writer. All other labor required was furnished from the company force, by its Assistant Superintendent of Grounds, but under the direction of the superintendent for whom they were used. The entire working force was carried on the company's payroll, but (with the exception of its own men) the men were paid off at the office on the building.

Requisitions for the stock were [illegible] company's purchasing agent, all [illegible] done by him, subject to the ap[illegible] General Superintendent. In this [illegible] were reduced to a minimum, there [illegible] for an inspector, no arguing over [illegible] no attempt to slight the work. It [illegible] bination making for the very best [illegible] at a low cost, and is without do[illegible] satisfactory way for a large c[illegible] handle its construction and repairs.

The mill is 430 ft. 8 ins. long, [illegible] ft. wide, with two stories and a high basement [illegible] the basement is 280 ft. long and 11 ft. 2 in[illegible] ch. The other stories are 17 ft. high. T[illegible] plant includes also the gas producer plant, [illegible] ne room and fan room. About 2,400,000 c[illegible] t bricks were used in this work. About 17,0[illegible] barrels of cement were used, 7,500 barrels b[illegible] for the bricks, 1,338 barrels for the engine [illegible] foundation, and about 1,300 for the gas pro[illegible]er foundations. Work was started Oct. 1, 1906. The buildings were ready for the roof by J[illegible] 1, 1907, and they were in operation early in the spring of 1908.

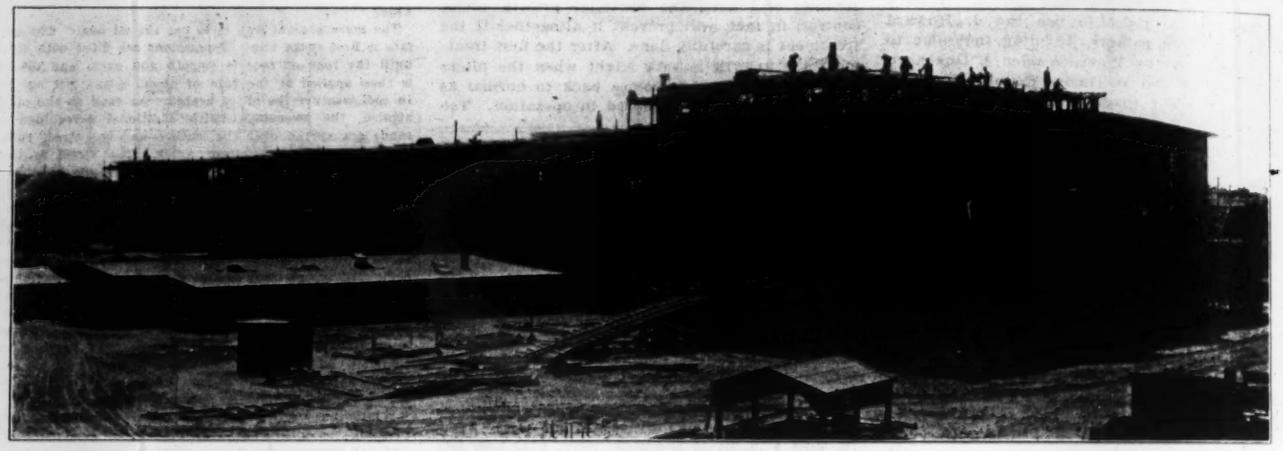


FIG. 1. A LARGE MILL BUILT OF CEMENT BRICKS; MILL NO. 3 OF THE PLYMOUTH CORDAGE CO., NORTH PLYMOUTH, MASS.
(The two sheds contain the brick-making plant and the curing racks. The inclined runways are for hauling brick directly into the building, no hoists being used.)

Fig. 1 is a general view of the building under construction, with two sheds of the brick making plant. Fig. 2 shows a part of the two-story portion. Fig. 3 is a plan of the smaller brick shed, containing the brick machines. Fig. 4 shows the curing or drying racks in the shed, with the pipes for heating the shed. It will be seen that this plant was close to the building. In fact, nearly a million bricks were taken directly from the racks and piled in different parts of the building, so as to be ready for use. The bricks were taken into the building by carts on inclined runways (as shown in Fig. 1), thus dispensing with the use of hoists. Some of the sand used was excavated at the site, the remainder was hauled from the company's sand bank at a little distance from the site. The manufacture of the brick began simultaneously with the work on the foundations, during the first week of October, 1906.

The smaller shed, containing the machines, had in it sufficient rack room for about 13 hours output. During the winter months, the larger shed was used, making a total capacity for 26 hours output. In winter, no bricks were piled outdoors, there being storage room inside for nearly 500,000 bricks. They were kept constantly sprayed with water to prevent rapid drying, but with sufficient heat in the building to keep them from freezing. During the warm weather, bricks were left in the racks only over night; in cold weather, 48 hours.

The bricks were made in four Standard cement-brick machines, operated by hand. Each machine made 20 bricks at a time. The horizontal plane at the under side of the machine was formed by a sheet metal pallet; wooden pallets were tried, but the warping of the wood

*5530 Cornell Ave., Chicago.

cracked bricks. Steel plates on the vertical plane the sides of the mold. Tamping was done hand, mortar leveled to the top of the plate and then by heavy pressure from a hinged ney were given 3/16-in. more compression the face side, making firm compact bricks 3⅞ × 8 ins. After compression, the

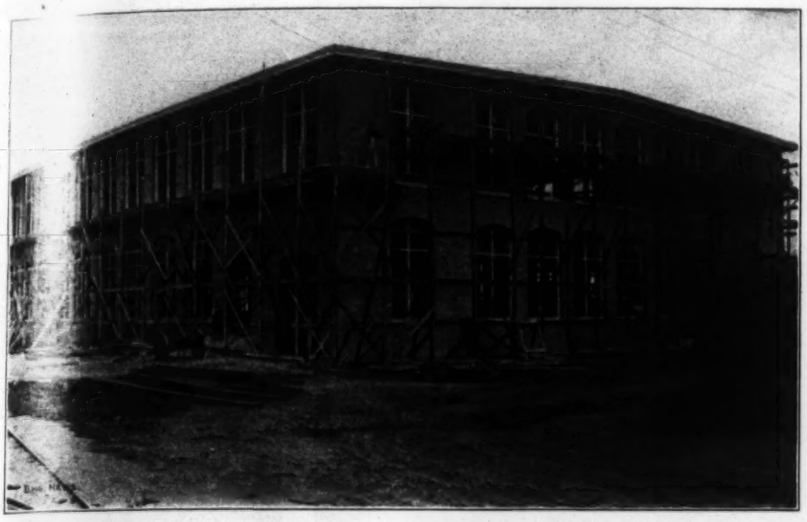


FIG. 2. A CORNER OF THE CEMENT-BRICK BUILDING, SHOWING THE GENERAL APPEARANCE OF THE FINISHED WORK.

vertical plates were drawn by a lever, the front of the machine was dropped, and the pallet with 20 bricks was placed on the racks. The complete operation for common brick required about three minutes.

The mixture used in the major part of the work was 3 parts sand to 1 part cement. A few bricks were made of 4 parts sand to 1 cement,

TABLE I.—ABSORPTION OF CEMENT BRICKS.

Brick.	Weight—Dry. lbs.	oz.	Saturated. lbs.	oz.	Absorption. oz.
Face	5	8½	5	10	1½
Common inside	5	8	5	11	3
Facing material*	5	9½	5	10	½
Hard burned body clay brick	4	11	5	7	12

*Brick made entirely of the material used for facing the outside brick.

for lightly loaded walls. The brick used on the outside of the buildings had a facing (⅛-in. thick after compression) of 2 parts fine sand and 1 part cement, with the addition of 2% waterproofing (by weight) to the cement. Enough water was used to make a mortar of such consistency that it would hold its shape under compression, without flushing water to the surface so as to cause the mortar to stick to the plates. No definite percentage can be given as to the amount of water, as that is governed largely by temperature and atmospheric conditions, but the average amount was about 8%. Care in curing the brick (that is, constant wetting), will overcome to a large degree any minor weakness which is theoretically developed by a "dry mix."

To the uninitiated, the small quantity of water used would seem likely to produce a porous brick having a strong attraction for water, with damp buildings as the result of their use. As a matter of fact, these bricks do not absorb water to any great extent. Bricks 30 days old, carefully dried and then submerged in water for 16 hours, showed the results given in Table No. 1.

Table No. II. shows the results of tests made under the direction of the Ordnance Department of the U. S. Army at the Government Arsenal in Watertown, Mass. The figures are averages, unless otherwise noted.

TABLE II.—TESTS OF CEMENT BRICKS.

Test "A." Face brick; body 3 parts sand to 1 part cement; facing, 2 parts fine sand to 1 part cement; 2% waterproofing compound added to cement by weight. Facing ⅛-in. thick after compression.

Age, days.	1st Crack, lbs.	Ultimate strength, lbs.	Per sq. in. lbs.
56	87,100	87,100	2,730
120	109,900	108,650	3,400
239	128,500	132,650	4,145
Test "B." Common brick; 3 parts sand to 1 part cement.			
56	69,750	71,200	2,215
92	95,000	99,100	3,080
120	119,700	119,700	3,735
239	129,000	134,100	4,005
275	162,100	164,600	5,160
Test "C." Common brick; 4 parts sand to 1 part cement.			
56	74,150	76,500	2,390
120	89,050	91,450	2,810
239	119,500	126,400	3,905
Test "D." Common brick; 5 parts sand to 1 part cement.			
56	72,150	72,150	2,240
120	80,700	86,650	2,675
239	110,000	119,950	3,710
Test "E." Two hard-burned "body" clay bricks.			
...	131,000	150,000	4,770
...	154,000	162,000	5,470

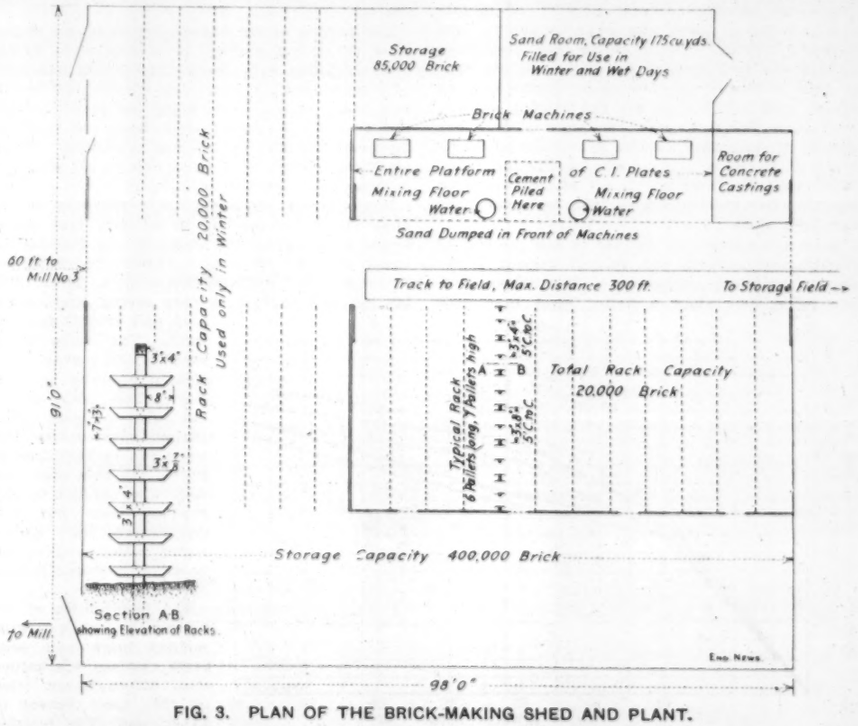

Storage 85,000 Brick
Sand Room, Capacity 175 cu yds. Filled for Use in Winter and Wet Days
Brick Machines
Entire Platform Mixing Floor Water
Cement Piled Here
of C. I. Plates Mixing Floor Water
Room for Concrete Castings
Sand Dumped in Front of Machines
60 ft to Mill No 3
Track to Field, Max. Distance 300 ft.
To Storage Field
Rack Capacity 20,000 Brick Used only in Winter
Typical Rack 6 Pallets long, 7 Pallets high
Total Rack Capacity 20,000 Brick
91'0"
Storage Capacity 400,000 Brick
Section AB showing Elevation of Racks
to Mill
Eng. News
98'0"

FIG. 3. PLAN OF THE BRICK-MAKING SHED AND PLANT.

The best test on a 3 to 1 brick shows 5,460 lbs. per sq. in. The best on a hard burned "body" clay brick showed 5,470 lbs. per sq. in. The average on the clay brick was 5,120 lbs., or slightly less than that for the average cement brick at nine months.

Two bricks made at the same time, from the same stock, show varying results. For instance, two bricks (3 to 1) 275 days old; first crack at 155,200 lbs. and ultimate strength 155,200 lbs.; first crack at 169,000 lbs. and ultimate strength 174,000 lbs. Compare that with the clay bricks; first crack at 94,000 lbs., and ultimate strength 162,000 lbs.; first crack at 101,000 lbs., and ultimate strength 150,000 lbs. Average results show the first crack to be at 0.974% of the ultimate strength for 3 to 1 cement brick, 0.90% for 4 to 1 brick, and 0.943% for 5 to 1 cement brick; and 0.625% for clay brick. The lowest percentage shown in any cement brick was 0.870%.

Six kinds of cement brick were made and used: (1) common brick, output 13,500 to 14,000 per day; (2) face brick, 9,400 to 9,800 per day; (3) 2-in. radius brick for inside jambs, 8,400 to 8,800 per day; (4) outside corner brick (face and one end waterproofed), 8,000 to 8,400 per day; (5) headers, with one end faced, for arches and header courses, 9,000 to 9,400 per day; (6) white brick (faced with white cement for interior of the engine room), output the same as for the face brick.

The "tare," that is brick which cracked in the molds, was about 0.5% of the gross output. These bricks were not a loss, as they were used in the middle of the walls. The only actual loss came from the pallets of the brick near the ground. When these were "green" they were attacked ravenously by rats, as many as 20 bricks being destroyed in a night.

The mortar for laying the brick was mixed in proportions of 3 parts sand, 1 part cement, and ⅛-cask of lime to each barrel of cement. This made a mortar strong, rich and easy to spread on the wall. Possibly it was too rich; that is a matter for argument. When the arches were turned over the basement windows the first floor was not ready, so the walls were run to the sill height on the next floor. Within a few days, cracks developed in some of the arches, continuing to the top of the wall then laid, and showing on either side. Enough of the wall was taken down to repair with new work that which had cracked, and no further cracks de-

veloped in the basement. Wide spread footings 4 ft. 6 ins. below grade, on a firm dry sand and gravel foundation, eliminated the possibility of the cracks having been caused by settlement. Shrinkage was the only alternative cause.

The rowlock arches were spaced for a 3/16-in. joint on the extrados of each ring, but it was practically a fruitless task trying to keep the bricklayers to this spacing. The size of mortar joints may or may not have been a factor in causing shrinkage; that is a matter which will not be argued here. Nor will the merits of suggested preventatives be discussed; these suggestions included continuous horizontal steel reinforcement or dry cross joints on the face, and making an expansion joint such as is employed in monolithic concrete walls. The method employed was experimental, but proved simple, effective, and economical. The piers were 3 ft. wide, windows 8 ft. wide. By leaving out the key brick in arches 44 ft. c. to c., no more cracks developed in the other two stories, with one exception noted later. Three or four days after laying (governed by the drying temperature of the air), the arches were keyed, and the work on the wall continued.

On the north wall, 430 ft. 8 ins. long, the distance from the corner to the center of the first opening from the east was 16 ft. Shortly after the second story was under way, a crack developed in this arch. It was repaired and when the building was completed, showed free from cracks. Some months after, a crack showed at this point in the two upper stories, more distinctly on the outside. It is a question as to whether this individual crack was caused by shrinkage or by settlement.

One blank partition wall 114 ft. long, 24 ins. thick and 45 ft. high, developed a number of fine hair cracks running from 5 ft. to 15 ft. above the foundation. These were visible on one side only. Another wall of the same length and height, and of varying thickness, with but two openings 8 × 13 ft., showed in the end farthest from the openings a vast number of minute cracks. One of these was large enough to take pointing mortar. These cracks ran diagonally toward the free end of the wall. On one side of this wall was the fan room, containing the steam coils and blower for the heating system. On the other side, was the rope alley. The cracks showed only on the rope alley side; no trace of cracks was to be seen in the fan room. With the exception noted, all cracks appeared shortly after the walls were laid, and none have appeared since.

Bond is an essential feature in any method of construction, and in this respect cement bricks appear to great advantage. Clay bricks with one pallet side show a better bond than clay brick with both sides perfectly plain. It might be argued that cement brick with plain bed and build would furnish an inferior bond with the mortar. The fact is, however, that the cement brick is perfectly in bond with the mortar, to such a degree that the resulting wall is practically monolithic. Owing to the bond, attempts to make cleanly cut openings in old work were a failure, unless great care was taken to first cut out the joints. If this was not done, the wall was defaced. Holes drilled through the wall would split out on the other side a space oftentimes over a foot square, especially when drilled from the inside. If mortar was left on the brick in laying, it was impossible to clean it off with any reasonable amount of water and acid, and it could not be scraped off without defacing the wall.

The cutting of the cement bricks is one of the most valuable features. It is possible to do almost anything with them. The writer has seen cuts made half an inch thick, for the full length and width of the brick; ¼-in. cut from the full bed of a brick (except ½-in. from the face) to lay over and hide the edge of a casting. These are things which it is impossible to do with the ordinary clay brick.

In the laying of cement brick, anything can be done that it is possible to do with face brick, every brick being the same in all dimensions, equal in appearance and quality, requiring no "culling." For ordinary work, ¼-in. joints, 13⅛ ins. for five courses, is easy laying, and makes neat and smooth looking work. The color is a beautiful mild gray, subject to staining perhaps more than clay brick, but with ordinary care during construction the walls can be kept free of stains. In this case, one wall was subject to the exhaust from gas engines, and that shows stains which undoubtedly would be found in any case.

The possibilities of ornamental work with molded brick and concrete castings are unlimited, although not tried on this plant except in experiment. The interior of the engine room is lined with white brick made by facing the ordinary brick with white cement; the pilasters have base, pedestal and cap of the Tuscan order cast in white cement.

About 2,400,000 cement bricks were used. Comparison of the cement brick with clay brick show to the advantage of the former. In compression, the cement brick nine months old average 40 lbs. per sq. in. more than the [illegible] load carrying sections of clay bric[illegible] built of "body" brick, but of "light hards," far inferior in qu[illegible] brick. Clay brick are disintegrat[illegible] rain, cement brick become hard[illegible] thereby lessening the cost of ma[illegible] this plant, the brick were made at an average cost of 12% less than clay brick could have been bought for at the time. It is the opinion of the writer, backed by actual experience, that for any ordinary building work these brick can be made safely in proportions of four and five parts sand to one of cement.

FIG. 4. INTERIOR OF BRICK SHED, SHOWING THE ARRANGEMENTS OF RACKS FOR DRYING AND CURING THE BRICK.

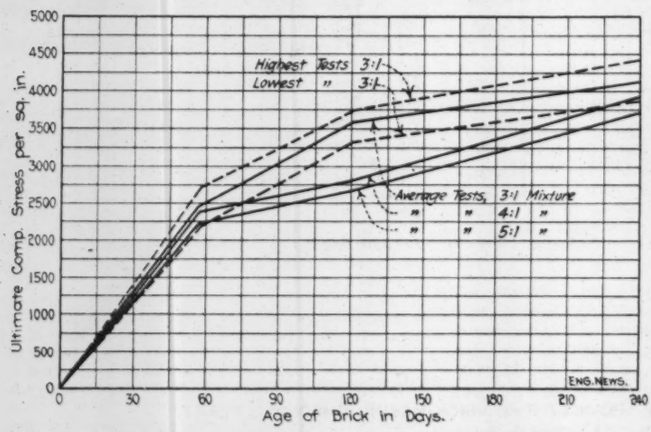


FIG. 5. DIAGRAM OF RESULTS OF TESTS OF CEMENT BRICKS.

Brick Paving and Street Railway Track Construction at Champaign, Ill.

The use of brick paving is very general in towns and cities of the central states, and in many cases it is adopted for streets having electric railway tracks. Different methods of construction are employed in these cases, a specially substantial foundation being employed when tracks have to carry the heavy cars of interurban electric railway. In the paving of John St., Champaign, Ill., some special features of construction have been employed: (1) The tracks consist of T-girder rails laid upon concrete beams or longitudinals built in advance of but incorporated with the concrete foundation for the paving; (2) each groove for the wheel flanges is formed by two lines of bricks (both laid as stretchers but breaking joints), one fits under the rail head and projects far enough to form the bottom of the groove, the other forms the side of the groove; (3) asphalt filling is used for that part of the brick paving between the rails and tracks and for 18 ins. outside of the rails. Cement filling is employed for that part of the paving at the sides of the street; (4) the paving bricks are laid as stretchers between and outside the rails, but as headers between the tracks (on double track) and at the sides of the street.

The paving extends for half a mile, about one-third of the distance having double track, another third single track, and the remainder having no track. The construction is shown in the accompanying cut. It was described by Mr. G. C. Fairclo, City Engineer, in a paper read at the recent annual meeting of the Illinois Society of Engineers and Surveyors, and from this we take the following particulars:

The pavement along that part of the street upon which car tracks are laid is 36 ft. wide between outside curb lines, and along each side of the pavement is built a combination concrete curb and gutter 23 ins. wide. The

curb [illegible] ins. thick leaves a clear roadway of 35 ft. 10 ins. Where double track is laid, the distance between centers of tracks is 12 ft. The cars are 8 ft. wide over all, making the distance from the center of the pave-

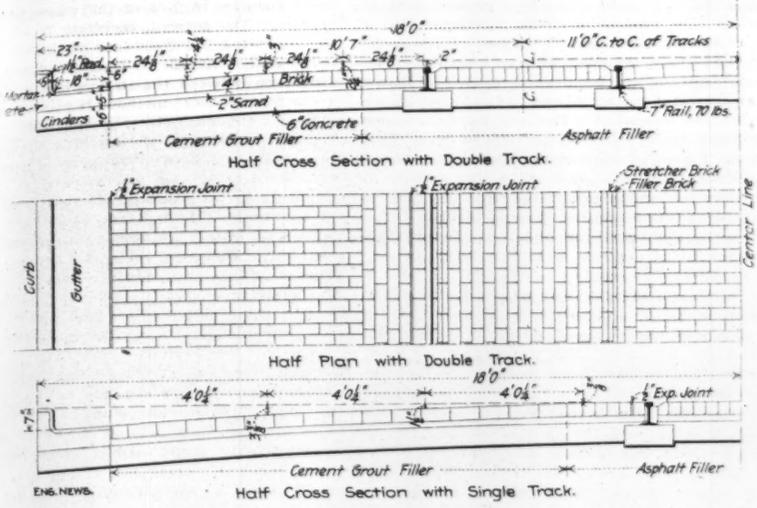


FIG. 1. CROSS SECTIONS OF BRICK PAVED STREET WITH RAILWAY TRACKS AT CHAMPAIGN, ILL.
G. C. Fairclo, City Engineer.

ment to the outside of a car passing along the street, 10 ft. 3 ins. This leaves a space of 7 ft. 8 ins. between the car and curb, which is sufficient for the passage of vehicles. It would probably be desirable to add 2 ft. to this space, making the pavement 40 ft. over all, were it not for the desirability of keeping the assessment on the abutting property as low as possible.

The subgrade was prepared in the usual way, being rolled with a 10-ton steam roller. On the subgrade was placed a 6-in. foundation of broken-stone concrete. The concrete was made of 1 part Portland cement to 12 parts aggregate, and was mixed in a Foote continuous mixer. A 2-in. sand cushion was used on the concrete foundation and the street was paved with Culver block made by the Wabash Clay Co.

The interstices between the brick on that part of the pavement lying beyond five courses of brick outside of the rail are filled with a grout filler consisting of 1 part cement and 1 part fine sand. The interstices between the brick of that part of the pavement lying between these lines and along the track are filled with Pioneer asphalt filler.

The ties under the track were well seasoned oak ties 6 x 8 ins., 8 ft. long, except that sawed switch ties were used at the turnouts where the double-track joins the single track. It had been expected that sawed ties treated with creosote oil would be used, but the traction company was unable to secure them. The ties under the track were spaced 5 ft. c. to c., excepting at the joints. A tie was placed immediately under the joint, and the ties on each side were spaced half way between the joint tie and the second tie on each side. The switch ties at the turnout were placed 20 ins. c. to c., it being considered necessary at the turnouts to spike the rails every 20 ins. on account of the lateral thrust given by the car on the curve. The rails were 70-lb., 7-in., T-girder rails, 60 ft. long, made by the Pennsylvania Steel Co.

The subgrade was finished as if no car track was to be built along the street, and center stakes were set to line and grade every 25 ft. Transverse trenches spaced 5 ft. c. to c., were then dug to a depth of 19 ins. below grade. These were 9 ft. long and 18 ins. wide, and were filled with concrete to a depth of 6 ins. to form foundations for the ties. Under the position of each rail and between the transverse trenches, a longitudinal trench was dug 16 ins. wide and to a depth of 15 ins. below grade for a foundation slab or beam of concrete 8 ins. thick and 16 ins. wide.

As the trenches were completed, the ties and rails were placed, the joints of the rails being broken 30 ft. and the rails spiked in place. The track was then lined and graded to the surface of the pavement. To raise the track to the required grade, blocks were placed under the ends of each tie, and with the aid of shingles the track was brought to the required grade. This method of blocking up the track made it stable enough to carry the concrete mixer, which was mounted on flanged wheels.

The concrete was placed first in the trenches under the ties and rails, and a foreman with three men furnished by the traction company thoroughly tamped the concrete under ties and rails, using shovels and tamping bars. The concrete foundation between the ties, and the foundation for the roadway on each side of the track, were constructed at the same time, being kept only far enough back to allow thorough tamping of the concrete previously laid under ties and rails. The surface of the concrete was brought to the exact contour of the pavement by means of forms or templates dragged over the concrete; there was one for each side of the roadway, one between the tracks, and one between the rails. The templates for the roadway were constructed so that one end rested on the concrete gutter and the other end on the rail. The ends of the templates used between the tracks and between the rails rested on the rails. The runners which carried the template were shod with steel and were made adjustable, so that the templates were used also to level the sand cushion. By using these templates the wavy surface which is often seen on a brick pavement was obviated.

Where a single track is laid along the street, the bricks between the rails and for five courses outside of each rail are laid longitudinally along the street and parallel to the rails. From the face of the gutter flag to a line five courses outside of each rail, the brick are laid at right angles to the curb; at street intersections, however, they are laid at an angle of 45° to the curb. Along the double track, the bricks between the rails of each track and for five courses outside the outside rail of each track are laid longitudinally. Between the inside rails of the tracks (with the exception of one course of brick which is laid longitudinally), the bricks are laid at right angles to the curb line. From the gutter flag to a line five courses outside the outside rails the bricks are laid at right angles to the curb line.

The grooves for the car tracks are formed by the use of filler and stretcher brick manufactured by the Nelsonville Brick Co. The filler brick fits the web of the rail, and in combination with the stretcher brick which is laid parallel to the rail and against the filler brick it makes the proper groove for the car wheel flanges and presents a very neat appearance. Asphalt filler was used between lines five courses outside the outside rail of each track, as already noted. The object of this was to lessen the noise made by the cars passing over the track, also to facilitate the repair of the track, as the bricks may be removed without breaking, the filler preserved and remelted, and both replaced in the pavement.

To take care of the expansion in the grout-filled pavement, expansion joints were constructed as follows: Where single or double street car tracks are built along the street, ½-in. expansion joints are constructed along the face of the gutters, between the first and second rows of brick outside the rails of a single track, and between the first and second rows of bricks outside of the outside rails of the double track; also every 25 ft. across

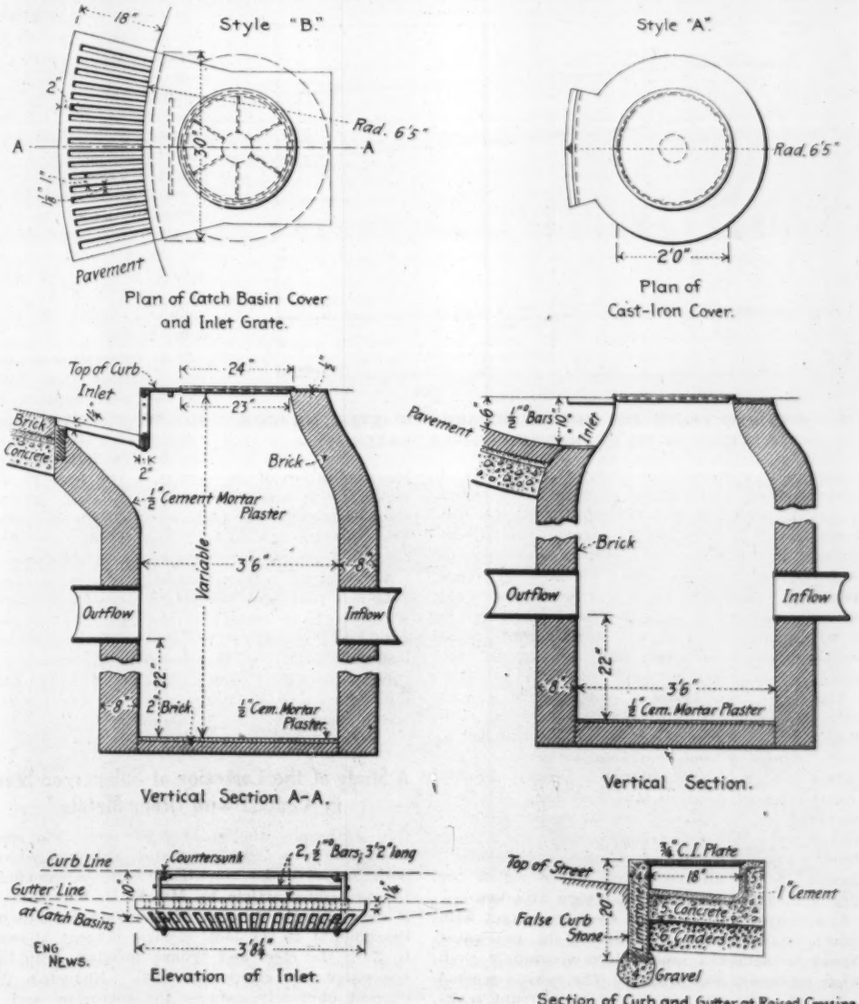


FIG. 2. CATCHBASINS AND GUTTER CROSSINGS ON JOHN ST. IMPROVEMENT; CHAMPAIGN, ILL.

the pavement, extending from the gutter flag on each side to a line five rows of brick outside the rail.

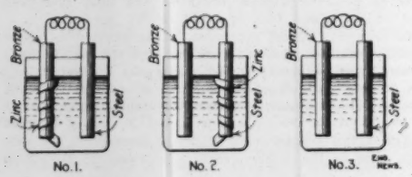
The prices bid for brick pavement on John St. (on which car tracks are built) are as follows: Brick pavement with 6-in. broken-stone concrete foundation, grout filler and expansion joints, $1.62 per sq. yd.; the same, but with asphalt filler, $1.73 per sq. yd. The price bid in 1907 for brick pavement with 6-in. broken-stone concrete foundation, grout filler and expansion joints (but without car tracks) was $1.58 per sq. yd. The same contractor did the work in both cases, and states that the delay occasioned by surfacing the tracks entails a labor cost of at least 5 cts. per sq. yd. on account of time lost.

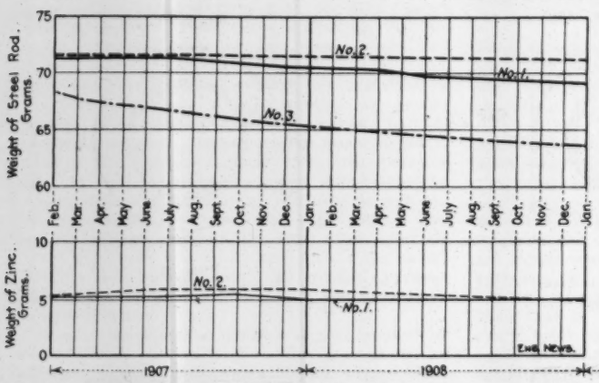
The pavement has been in use since Sept. 1, 1908, and as yet has not passed through the hot summer weather, at which time the rumbling noise due to expansion in grout filled pavements is most noticeable. However, up to this time the passing of cars over the tracks and of vehicles over the street has made no more noise than in passing over a street with a sand filler.

Experiments on the Corrosion of Steel in Contact with Bronze in Sea-Water.

By EDWARD C. SHERMAN,* Assoc. M. Am. Soc. C. E.

In designing the lock-gates for the Charles River Dam at Boston, several problems arose upon which no adequate and reliable information was available. In the description of the gates, which appeared in the Engineering News of July 9, 1908 (p. 29), it was stated that Parson's manganese bronze had been used for truck axles, as it possesses the physical properties of medium steel without the certainty of serious corrosion, which would interfere with the free turning of the axles in the boxes. But as sea-water acts upon metals much as does a weak acid, it was suggested that the use of bronze axles in connection with a steel structure might result disastrously to the steel plates and shapes of which the gates are made up on account of an electrolytic action which paint would not appreciably prevent.





RESULTS OF TESTS ON THE CORROSION OF STEEL IN CONTACT WITH BRONZE UNDER SEA WATER.

Although there exists a considerable amount of engineering literature on the corrosion of metals, little information of value, bearing on the amount of such galvanic action as might obtain here, could be obtained. A case was discovered where a steel ship had been seriously corroded in the vicinity of its bronze propeller and near a brass strainer plate over a condenser pipe until plates of zinc had been attached to the affected parts, after which the zinc, instead of the steel, had been attacked.

It appeared probable that steel in contact with brass or bronze and immersed in sea-water would be attacked much more vigorously than when no bronze was present. The subject seemed to be of sufficient importance to warrant making some actual tests of the effect of using zinc to protect the steel in such cases. These tests were made in the laboratory of Mr. Herbert L. Sherman, Analytical Chemist, Boston, and the results showed us so conclusively that steel in contact with bronze may be protected by a proper use of zinc, that the axles of the lock-gates have been wrapped with zinc sheets.

The results of the tests are graphically shown by the accompanying figure, which also shows the method employed. The electrolytic couples used were made up of ⅝-in. rods of rivet steel and of Parson's manganese bronze, connected at their tops with copper wires and placed in glass jars containing salt water from the Charles River near its mouth at Boston harbor. The rods were immersed for about 4 ins. of their length. The zinc strips were ⅜ × 10¾ ins. and were entirely immersed.

In test No. 1, the zinc was wrapped around the bronze; in No. 2, around the steel; and in No. 3 no zinc was used. Small strips of commercial sheet zinc were used. The weights of the steel, zinc and bronze have been recorded at frequent intervals during the two years the tests have been running. The bronze has not been appreciably affected and the loss of weight in the zincs is much less than it was expected to be, but this may be due to the formation of a zinc oxide which adheres firmly to the metal. The weight of the oxide then masks the amount of actual deterioration. The loss of weight of steel in the cell having no zinc protection (No. 3) is a very considerable percentage of the original weight as the diagram shows, while in neither of the cells with zinc strips is the loss very noticeable. Indeed, a slight gain appeared for a time in No. 1, due to the formation of oxide, which later fell to the bottom of the jar.

The supply of sea-water, while not frequently changed entirely, has been renewed regularly at intervals of three or four weeks, to replace losses by evaporation and to prevent an approach to chemical equilibrium when the rate of corrosion would be reduced. This reproduces the main conditions of actual practice as well as could be done conveniently under the circumstances.

It is interesting to see that putting the zinc on the steel appears to give better protective results than putting it on the bronze, but in making application of the results of the tests to the lock-gates it was impossible to do this. As the steel parts could not be covered satisfactorily the next best thing was done, and the bronze axles, as stated above, were wrapped with zinc sheets.

Although the tests described have already given evidence that zinc protection plates are worth while, it is proposed to continue the batteries until the steel rods or the zinc strips are entirely consumed. It is to be admitted, of course, that these studies have been incomplete, but it seemed unnecessary to carry the work further for the end in view.

*Division Engineer, Charles River Basin Commission, 367 Boyleston St., Boston.

A Study of the Corrosion of Submerged Steel in Contact with Other Metals.

In examining the problem of protecting steel work submerged in sea-water and in contact with bronze under conditions such as shown in the preceding article by Mr. E. C. Sherman, it is seen that the amount of corrosion depends on the amount of the local electric current allowed to flow, the steel and bronze forming, with the sea-water, an electrolytic cell. Reducing the current obviously reduces the corrosion, and it is worth while to enquire in what ways the current can be reduced.

The current is caused to flow by [electro-]motive force excited between the [metals] by the electrolytic arrangement. [This] simple obedience to Ohm's law [is] the resistance to flow of the whole [circuit] current. The current, therefore, is [diminished] by increasing the resistance of the [electrical] paths and (2) by decreasing [the potential] difference between the two metals in [contact].

The first of these methods is probably [much more] difficult, though both are very difficult [under] present knowledge if anything like [complete] protection is desired. The path of [the current] current consists of two general parts to [which attention] may be directed; (1) that from [the iron] to the bronze through the liquid and [that] from the bronze to the iron through [metallic] contacts. Consider the first general [division]. The resistance may be increased by [increasing] the submerged area of either or both [metals], if such a thing be possible. The same thing would be accomplished if we had a perfectly impervious paint, something which has not yet been brought forward—at least commercially. There is some increased resistance by heavy coating of as nearly impervious paint as can be obtained. This coating then acts as a porous membrane and probably would require frequent and thorough renewal. At best it would be expected to have only a comparatively small additional effect.

In most practical cases it will be found that the metallic connections between bronze and steel are permanent and beyond change. In the cases where such is not the case the resistance of the metallic path may be greatly increased by the insertion of insulating media between the bronze and steel work.

Turning to the other means of decreasing current—by decreasing potential difference—promise of somewhat fuller success is seen. The potential difference between the iron and bronze will be lowered by decreasing the electrolytic solution pressure of the iron, as the physical chemists would style it. A more popular way of expressing the same thing would be to say the iron should be polarized. This can be done by causing current to flow to the iron, and that is what happens when zinc is submerged in contact with the iron. The greater the current made to flow to the steel, the greater the degree of protection, and we can increase the current by decreasing the resistance of the possible paths between zinc and iron in exact contrast to decreasing the current between iron and bronze. We are limited, however, to working with the zinc or we will decrease, at the same time, the resistance between iron and bronze. It is beneficial to have a large area of zinc placed as close to the iron as possible. Theoretically, the current flow, the polarization and the protection would all be greatest where the zinc and iron are closest. This is completely borne out by experimental studies. It is best, then, to spread the zinc at points about the submerged steel work that the protection may be extended as much as possible. The greatest possible distribution of the zinc would be by galvanizing. The galvanizing of large steel work such as grillage beams and columns has been successfully accomplished by the hot-process, as noted in Engineering News, Nov. 19, 1908. The obstacles in the way of the cold, or electrolytic, process for still larger pieces do not seem insurmountable. The one objection to galvanizing is that the zinc cannot be easily replaced as it becomes dissolved. Protection is obtained, of course, at the expense of corroding the zinc.

Another way of polarizing the steel comes to mind. This is at present not commercially applicable and should not be tried without expert advice, though it promises much for the future. The work of A. S. Cushman, of the U. S. Department of Agriculture, has shown that certain chemical compounds in solution, notably the chromates, have the power, when pure and without traces of acids, of inducing polarization in iron to which they may be applied. It may be possible to combine such chemicals, after their manufacture has been satisfactorily established, in paints which will serve as polar-

izers [illegible] moisture penetrates through them. This a[illegible]is not definitely certain with all the chroma[illegible]igments now obtainable.

One [illegible]er means of securing a low potential differe[illegible]between the steel and bronze parts lies in [illegible]use of nickel steel members. This, of course[illegible]n expensive construction warranted perhaps [illegible] the certainty of much longer life. Nickel [illegible] is fairly resistant to corrosion; its electrolytic solution pressure is low, the physical chemist would say.

The greatest possible degree of protection under the service conditions noted in the preceding article would seem to be, first, to use nickel steel members, secondly, to galvanize these members as heavily as possible, thirdly, to paint this steel work in place with a few good coats of an inhibitive paint, should the chemists soon perfect one, and on top of this to place several coats of the most nearly impervious paint obtainable.

Figures might be deduced, from the experiments noted in the previous article, for the amount of steel wasted per unit area of bronze immersed, or for the zinc wasted for a certain protection, but the foregoing discussion shows that they are really reliable only for the conditions existing in the experimental cells and hardly for the lock-gates in question, and certainly not for other practical installations. This does not indicate that some protection has not been secured, or would not be secured under similar conditions, but it does show that the amount of protection cannot be predetermined from these experiments. The only condition duplicated is that of potential differences between steel and bronze, the resistance of all paths and all polarization effects are conditions peculiar to each and every different installation.

U. S. NAVAL VESSELS under construction numbered 33 at the end of February. Of this number six are battleships, of which four are approximately 75% completed, and the other two just started; 15 are torpedo boat destroyers, of which five are more than half completed; eight are submarine torpedo boats, seven of which are about three-quarters completed; two are colliers and two are tugboats, all four of which are nearly ready for commission.

Improved Methods of Bleeding Pine Trees for Turpentine and Rosin.*

Among the leading industries of the Southern states are those related to the production and utilization of turpentine and rosin. As all the processes involved affect several million dollars' worth of timber each year, the United States Forest Service has conducted, for several years, special investigations into the methods of bleeding the trees and into the properties of timber from the bled and unbled trees.

FIG. 1. A "BOXED" PINE TREE.

The improved methods of turpentining were first established, to an appreciable extent, during the season of 1904, when a number of the most enterprising manufacturers of naval stores in Georgia and Florida were persuaded to substitute the "cup and gutter" system for the injurious and uneconomical "boxing" then practiced.

The old method, shown in Fig. 1, consists in cutting a cavity in the base of the tree to serve as a cup to catch the resinous sap. This cavity is usually some 14 ins. wide, 7 ins. deep and 3½ ins. from front to back, and two, three and often four boxes are cut into a single tree. This proves a severe drain on the vitality of the tree and also renders it an easy victim to ground fires and wind storms. Fig. 2 shows the result of boxing a tree beyond its ability to support its own weight during any disturbance.

The sap flows out from the cut in the sapwood which becomes clogged before long so that the cut has to be extended higher and higher. This necessitates the sap's flowing over a greater and greater area, as the season advances, so that much of the turpentine is evaporated and the resultant rosin is discolored by oxidation and contamination.

In Fig. 3 the newer method of using a "cup and gutter" is shown, though applied to a tree which had previously been boxed. Instead of allowing the sap to flow, in a thin broad sheet, down the whole wounded surface, it is received in a gutter just below the wound and led to a deep cup. Raising the cup and gutter as the wounded face is made higher, by the weekly chipping away of a ¾-in. strip of bark and sapwood, prevents loss of turpentine and deterioration of the rosin. This accounts for the increase in yield which has been demonstrated with the newer method.

Since the introduction of the cup and gutter there has been a steady increase in the percentage of turpentine and in the amount of rosin yielded from each grove where they are used. The following figures, giving the average yield of turpentine per crop of 10,500 boxes or cups in several states, suggests the extent of the improvement. Where the better method prevails, the greater yields are found.

	Yield per crop of 10,500 boxes.	Percentage produced by improved methods.
Alabama	35.6 casks	8
Florida	29.8 "	16
Georgia	26.5 "	9
Louisiana	44.7 "	44
Mississippi	34.5 "	11
Texas	43.5 "	49

In North and South Carolina improved methods are not in use.

The value of the newer method is further shown by reports from two large establishments in Texas; one using the cups and gutters and the other cutting boxes. The first concern reported a yield of 1,372 bbls. of turpentine for 20 crops, of 10,500 cuts, while the second reported a yield of 1,500 bbls. from 35 crops. This gives 68.2 casks of turpentine per crop for the cup and gutter method, as against 42.8 for boxing. Both of these concerns were operating for the first year and under practically identical weather conditions.

In Texas and Louisiana a great percentage of the lumber operators own their own timber land. Some of the most extensive tracts in these states are operated by large concerns which have carefully studied methods of bleeding the trees and the effect on the lumber product. These bleeding processes have been generally believed to decrease the strength and durability of the timber, and in many specifications timber from bled trees is excluded. The results of the studies of the Forest Service show conclusively, it is announced, that (1) bled timber is as strong as unbled if of the same weight; (2) the weight and shrinkage of the heartwood is not affected by bleeding; (3) the durability of the heartwood is not affected by bleeding, since the resin comes from the sapwood only.

U. S. FOREST SERVICE TESTS ON PROPERTIES OF NATURAL AND BLED LONG-LEAF PINE TIMBER.

	Number of tests made.	Specific gravity of test pieces.	Bending strength, lbs per sq. in.	Compression strength, lbs per sq. in.
Unboxed trees	400	0.74	12,358	7,166
Boxed and recently abandoned	390	.79	12,961	7,813
Boxed and abandoned five years	535	.76	12,586	7,575

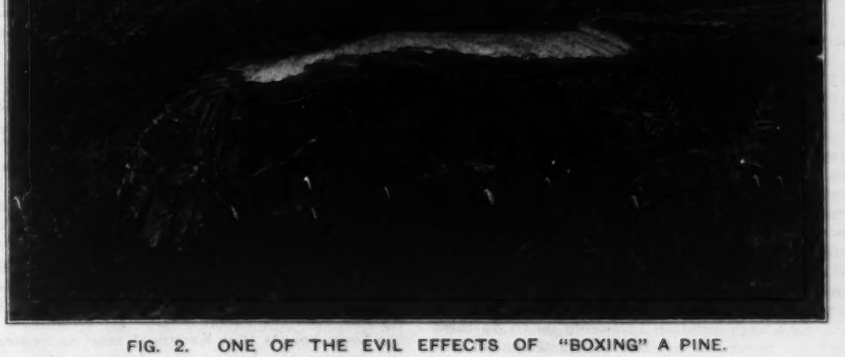


FIG. 2. ONE OF THE EVIL EFFECTS OF "BOXING" A PINE.

The accompanying table shows a remarkable similarity in the results of tests for three typical

*From information furnished by the Forest Service, U. S. Department of Agriculture, Washington, D. C.

groups of trees. Indeed the strength of the bled timber is larger than the untouched, though this is readily explained by the increase in weight.

The amount of resin in the wood varies greatly, and trees growing side by side differ within very wide limits. Sapwood contains but little resin (1 to 4%), even in those trees in which the heartwood contains abundance. In the heartwood the resin forms from 5 to 24% of the dry weight, and it cannot be removed by bleeding, so that the quantity remains unaffected by the bleeding processes.

FIG. 3. CHIPPING A WOUNDED PINE.
(Showing Cups and Gutters Attachedto an Old Boxed Pine).

The Highway Work of the Wisconsin Geological Survey.*

By W. O. HOTCHKISS.†

The first suggestion of the present highway work of the state geological survey came from President Van Hise, of the University of Wisconsin, who remarked to the writer in 1906 that the Wisconsin Geological Survey should take up the work of improving the roads of the state in the way the Maryland Geological Survey had done. A strong reason for immediate action was found in the fact that the legislature of 1905 had passed a resolution to amend the state constitution so as to permit the use of state funds for road-building purposes. Similar resolutions had been passed by earlier legislatures, but the succeeding one had always failed to agree, and as (in Wisconsin) a constitutional amendment must pass two successive legislatures and then be voted upon by the people, the matter had never come before the people.

The first thing to be done was to arouse interest enough to secure the passage of the amendment by the 1907 legislature, and if possible to secure an appropriation to enable us to do some work to secure a popular appreciation of the situation. With the very small amount of money that the survey could spare it was only possible to take a short trip around the state to see what the conditions were and write a report covering the facts as seen. In preparation for this report, (Bulletin XVIII, "Rural Highways of Wisconsin"), reports as to road conditions were received from town clerks, from the rural carriers (who were instructed by the Post Office Department to make the reports needed), and from several hundred farmers throughout the state. Articles were sent out also to about 600 newspapers in the state. The 1907 legislature passed the constitutional amendment, and also made an appropriation of $10,000 a year for the next two years.

To take charge of the work to be done under this appropriation, the Highway Division of the Geological Survey was organized. Owing to the fact that the money did not become available until August, 1907, it was impossible to do very much that year, and so we have actually been at work only a single season. The educational work has been carried on in a variety of ways. In addition to using the press of the state, as mentioned, we have had exhibits at the State Fair, have given road talks at farmers' institutes and other meetings, have organized the State Good Roads Association, and have distributed over 120,000 of our road pamphlets.

In 1907 we built a stretch of model macadam road at the State Fair, and in 1908, we had an exhibit of several forms of culverts and small bridges. These structures were left partially completed so as to show the forms and the method of placing the reinforcing bars. We also had photographs of completed roads and bridges, and sets of our standard plans of culverts and bridges.

During the road-building season, practically all our time has been given to the work of assisting town officers in building improved roads. We have surveyed new locations, made plans and specifications for improving old roads and supervised the construction in as many places as time would permit. Through arrangements with the manufacturers we have had three road building outfits to loan to towns during the past year, and with these have built stone or gravel roads in 13 places, aggregating a length of about 11 miles.

It has been interesting to watch the change in public sentiment as these roads have been under construction. In nearly every case there was only a bare majority in favor of the improvement at the beginning. But by the time the road was open for traffic the sentiment had changed so strongly that in several cases they have bought the machinery to continue the work when we could no longer carry it on for them. In all cases where we have built improved roads the people are planning to continue the work next year.

One of the most popular branches of our activity has been the bridge work. We announced to the town boards that we would send an engineer to examine the bridge site, draw up plans and specifications, make estimates, and assist them in letting contracts. The demand has been more than we could fill, in spite of the fact that two men gave their whole attention to this work. A set of standard plans for the ordinary spans of highway bridges has been made up and has greatly facilitated the work. While able to save considerable money the greatest good has been accomp ting them to build good strong bri of the flimsy structures too often e

Letters have been received from towns in which statements have bee the amount the towns have saved services. The estimates aggregate practically the whole amount of ou tion, and there are still 40 or 50 heard from.

The giving of free engineering a State is sometimes criticized as na legitimate field of the consulting en criticism is easily answered. In all we have found only one or two cas consulting engineer was called in town board. The town boards and who elect them do not appreciate th engineering services and so do not gineers. The work that we are doing part the creation in the mind of the a of the belief that the work of engi value in the ordinary town and coun bridge work.

I have made a study of the laws of other states having systems of state-aid for roads, and have drafted a bill providing for such a system in Wisconsin. The bill has been introduced by the senate committee on roads and bridges. Two of the most important provisions of this bill are: (1) The method of control of the state-aid work and (2) the method of distributing the aid.

Outside of the money expended for educational purposes and for the charitable and penal institutions, this state-aid for roads will be the largest single item of state expenditure, and there is necessity for most carefully safeguarding it to prevent it from being perverted for political purposes. The method adopted is that of putting general control in the hands of an ex-officio board of commissioners who hold their positions by virtue of holding some other non-political office. This is the method adopted by most states which have recently adopted a state-aid plan, and is recommended in a model state-aid bill sent out by the Office of Public Roads of the U. S. Department of Agriculture.

The active control of the work is put in the hands of a highway department at the head of which is the state engineer. This gives an efficient executive method. The state engineer would correspond to the president or active manager of a corporation and would act under the general direction of the commissioners, who would correspond to the board of directors. This system puts the public business on as efficient a basis as a private business. It gives one responsible head, chosen for his efficiency alone, instead of dividing the responsibility among several men.

From a study of the method of distribution of state-aid funds, it appeared that a method of allotment based on a single factor must of necessity strongly favor some counties at the expense of others. The system embodied in the bill is believed to do away with this injustice to the greatest possible degree. One-third of the total amount available for state-aid is divided in equal amounts, the same sum being allotted to each county. This division favors the small and the poor counties as compared to the larger and richer ones. Another third of the fund is divided among the counties on the basis of area. This division gives the larger counties a larger proportionate share of the money than the small counties. The last third is divided on the basis of assessed value, and obviously favors the rich counties, as they would get a larger proportionate share of the money than the poor counties. This three-fold allotment of the funds is adopted so that each class of counties will be favored in one of the allotments.

The staff of the Highway Division have inspected (at the request of town boards and others) 98 different roads and have surveyed 39 roads, 24 of which have been constructed. They have inspected 172 bridge sites, furnished 238 estimates of cost, and 56 of the structures have been constructed.

*Abstract of a paper read at the first meeting of the Wisconsin Engineering Society, held at Madison, Wis., Feb. 24 to 26.

†Chief of the Highway Division of the Wisconsin Geological Survey, and Secretary of the State Good Roads Association, Madison, Wis.

Bascu[illegible] Bridges Over the East Chicago Canal.

One [illegible]ne features of the industrial development f[illegible]e district at the south end of Lake Michiga[illegible]s the construction of the East Chicago ship co[illegible] from the lake to Indiana Harbor, Ind., in[illegible]er to provide for the delivery of ore at the [illegible]l works and to provide water transportati[illegible]ervice for the various manufacturing plants [illegible] other industries which are being established [illegible] and around that city. Near the lake, the [illegible] will cross four railways, the first being farthest from the lake: (1) Pennsylvan[illegible] Lines, 2 tracks; (2) Lake Shore & Michigan Southern Ry., 6 tracks; (3) Baltimore & Ohio Ry., 2 tracks; (4) Chicago, Lake Shore & Eastern Ry., 2 tracks. The canal is being built by the Indiana Harbor Land Co., and the company induced the railways to build drawbridges in advance, so as to avoid interference with the railway traffic and the canal construction in the future. There is, of course, no necessity for operating the bridges at the present time.

The first three railways, after considering the situation, decided to invite tenders jointly. The bascule type of bridge was adopted as the type that would best meet the requirements, and especially the requirement that additional tracks and bridges might be installed at a future time without interfering with the existing tracks and bridges.

Designs and proposals were accordingly invited by Mr. R. Trimble, Chief Engineer of Maintenance of Way of the Pittsburg, Fort Wayne & Chicago Ry. (Pennsylvania Lines; Northwest System). The offers submitted by the various bascule bridge companies and patentees were considered by a committee consisting of the chief engineers and the bridge engineers of the three railway companies, with Mr. Albert Lucius as their Consulting Engineer in this matter. The offer of the Strobel Steel Construction Co., of Chicago, for the Rall patented type of bascule bridge was accepted, as being the most economical and offering certain advantages in efficiency and simplicity of operation. A contract was accordingly awarded to that company for the construction of four double-track bridges (duplicates of each other): two for the Lake Shore & Michigan Southern Ry. and one for each of the other two railways. These bridges are described in the present article.*

The substructures were designed by the railway companies and consist of concrete piers supported on wooden piles. As there was no navigation, each road constructed temporary "run-around" tracks on a pile and timber structure so that traffic would not interfere with the work of constructing the substructure and erecting the superstructure. Sheet piling was driven to form cofferdams, and the enclosed material excavated to a depth of about 25 ft. The foundation piles were then driven, with the aid of the water jet, and the concrete for the piers was then deposited in timber forms. As the material penetrated was water-bearing sand, some difficulty was experienced on account of the washing away and undercutting of the sand.

Each bridge consists of a double-track, single-leaf, through-truss span, having a length of 86 ft. c. to c. of bearings. The general design of the bridge and its operating mechanism is shown in Fig. 1. The proportioning is in accordance with the specifications of the Pennsylvania Lines, which call for a live load of 60,000 lbs. concentrated weight plus a train load of 5,000 lbs. per lin. ft. of track. The weight of structural material in each bridge is about 313 tons, and that of the operating machinery is about 13 tons. The total rolling load of the bridge is 535 tons.

The special feature is in the swinging arrangement, which is covered by the patents on the Rall system. The bridge is of the movable center bascule type (as distinguished from the fixed trunnion type), and in opening it rolls backward as it swings upward. The pivot (A) is at the center of gravity of the moving structure, and forms the center of rotation. The principle will be understood easily by an examination of Fig. 1. The roller (B) is mounted on the pivot, and as the bridge revolves around (A) it moves backward due to the movement of translation of the roller (B) along the track girder (C) to the position (D). The two rollers (one to each truss) carry the entire weight of the structure when it is in motion or is standing in the open position. When the bridge is in the closed position it rests directly on the forward pin bearings at (E) on the pivot pier, and on cast steel shoes on the other pier. These bearings take the entire live load and part of the dead load with the bridge in the closed position. With the bridge closed, therefore, the roller is free and can be removed and replaced without difficulty. No pit is required to receive the tail or counterweight.

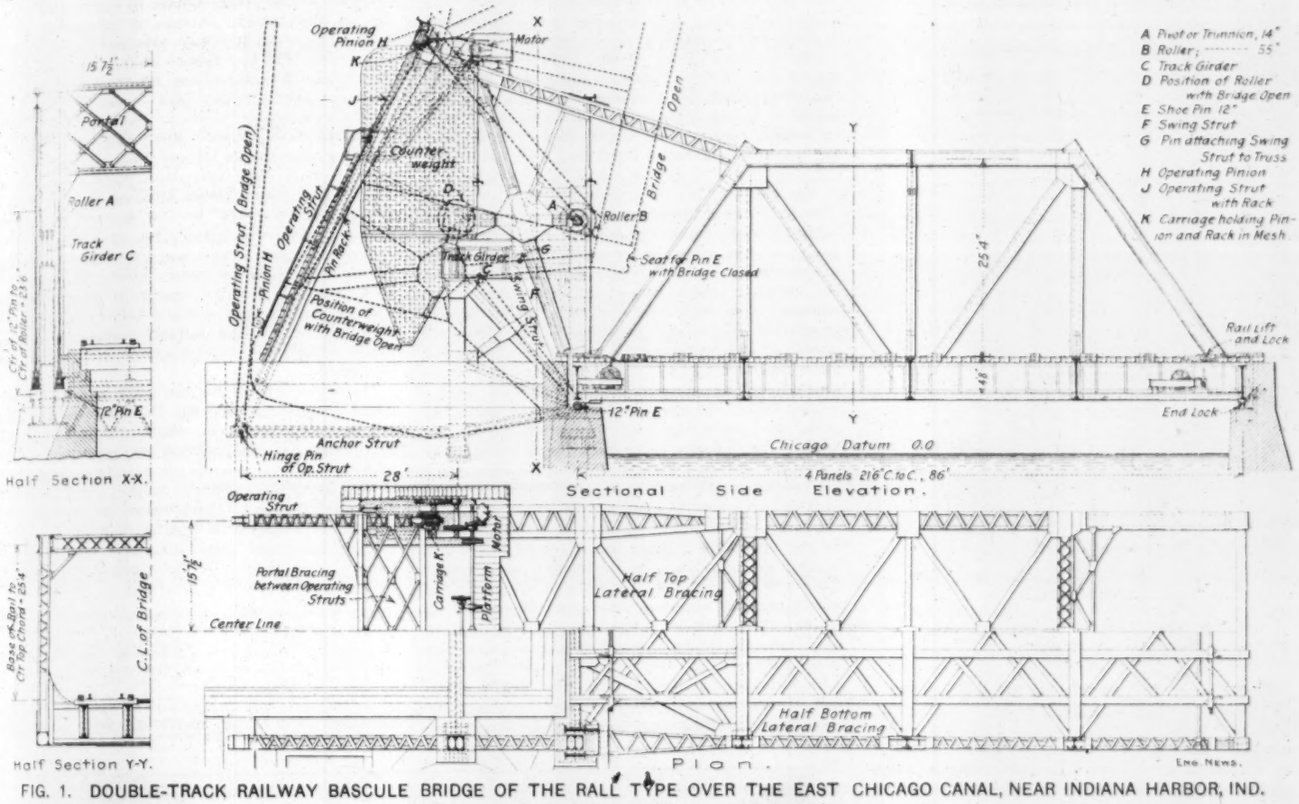


FIG. 1. DOUBLE-TRACK RAILWAY BASCULE BRIDGE OF THE RALL TYPE OVER THE EAST CHICAGO CANAL, NEAR INDIANA HARBOR, IND.

(There are four of these bridges over the canal.)

(Strobel Steel Construction Co., Chicago, Designers and Contractors.)

The distance of the horizontal travel of the pivot in opening the bridge is just sufficient to keep the tail clear of the masonry when the bridge is in the open position. In these bridges it is about 16 ft. This retractile motion of the bridge permits of the use of a minimum length of span, with a consequent economy in cost.

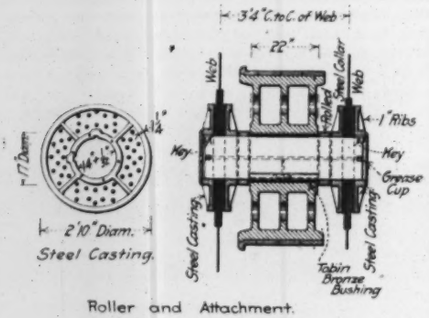
The counterweight consists of cast iron blocks for its lower third. These are bolted to a steel framework, which is continuous with and an integral part of the main trusses. The upper portion of the counterweight consists of stone-concrete in which pig iron is embedded. The concrete is reinforced with heavy wire meshing and tied together transversely by iron rods. Owing to the concentration of load made possible by the use of cast-iron blocks for a portion of the counterweight, it was found more economical to use them in this instance than to construct the entire counterweight of concrete, though the latter method would be preferable in some cases. Provision is made for attaching additional cast-iron counterweight blocks should changes in the weight of the track rails or other changes in the bridge require such additions. The total weight of the two counterweights of each bridge is about 340 tons.

The tail, or portion of the bridge from which the counterweight is suspended, is 28 ft. long. This is in the form of an irregular polygon, the forward portion of which is a triangular girder in which the trunnion or turning pivot (A) of the truss, is mounted. This pivot is also in the center of gravity and the center of rotation of

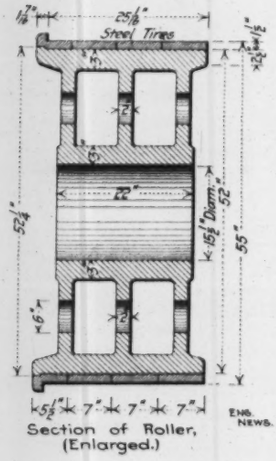
*The other two bridges are of the Scherzer rolling-lift bascule type. These are (1) the third bridge of the Lake Shore & Michigan Southern Ry. (which road has six tracks), and (2) the bridge of the Chicago, Lake Shore & Eastern Ry. These were built by the Scherzer Rolling-Lift Bridge Co., of Chicago.

the movable part of the bridge, as already noted. The motion is controlled by the swing strut (F). This is pivoted on the forward fixed pin support (E), and pin-connected to the triangular girder part of the truss at a point (G) somewhat back of and below the trunnion.

The bridge is operated by means of a pinion (H), mounted on the bridge and meshing into a



Roller and Attachment.



Section of Roller, (Enlarged.)

Fig. 2. Roller at Rall Bascule Bridges over the East Chicago Canal.

straight rack on the face of the operating strut (J). The latter is located at the extreme end of the bridge, back of the counterweight. It is hinged at the bottom to the foundation, and is free to move to accommodate itself automatically to the irregular curve described by the pinion in the tail of the bridge while in motion.

This method of applying the power is one of the special features of this design, and is claimed to result in considerable economy, as it avoids all irregular and expensive racks or tracks for the bridge operation, thus simplifying the work in the office, shop and field. The operating gear is held in mesh by means of a steel carriage (K) which travels along a track on the other side of the operating strut; it is connected with the axle of the main pinion and moves with it.

ROLLERS AND TRACK GIRDERS.—The trunnion (A), about which the bridge rotates, is carried by a roller or wheel (B) which turns around the trunnion. This roller is shown in detail in Fig. 2. It has a cast-iron center, on which are shrunk steel tires 1½ ins. thick. The journal bearing between the trunnion pin and the roller has a ¾-in. bronze bushing (with an easy fit on the pin), and is designed for a maximum pressure of 1,600 lbs. per sq. in. The trunnions are 14 ins. diameter and 4 ft. long. The rollers are 55 ins. diameter. Each roller has a smooth face 25 ins. wide, with a 1¼-in. flange at the outer edge to maintain the alinement of the bridge. The pressure on the roller is 22,000 lbs. per lin. in.

The track on which the roller travels is straight and short. As the operation is controlled by the swing strut (F), previously mentioned, there is no necessity for projecting lugs or cogs to keep the bridge from getting out of position. The track plate (1¼ × 25 ins.) is made continuous and without joints, as shown in Fig. 4. The track girder (which carries the bridge while in motion) has three webs with side plates and six 12-in. channels in the top chord in order to provide proper rivet areas for the large concentrated loads. The girder is filled with concrete. When the bridge is closed, the roller bears but lightly on the track. Consequently the live and dead loads are not carried by the trunnion and track girders, but are carried by the forward pin support (E) and by the bearings at the opposite end of the bridge.

LOCKS.—When the bridge is closed, each truss is secured at the farther end by an end lock. This is a bolt of rectangular shape operated by a transverse shaft which connects both locks and is operated by gearing and a worm-wheel from an independent motor which is controlled by the operator on shore. This apparatus is so designed and interlocked with indicator signals that the operator knows when the locks are either shot or drawn. Should he overlook the signal and fail to stop the operation, the bolts will continue to move in and out without breaking any of the parts.

Each bridge is provided at both ends with rail locks for each track. These are of the standard design of the L. S. & M. S. Ry. for that company's bridges, and of the standard design of the Pennsylvania Lines for the other two bridges. The rail locks for each bridge are so connected by means of levers that they are operated simultaneously. They are moved by an independent motor controlled from the operator's house on shore in the same manner as the bridge locks. Means are provided for operating both the rail locks and bridge end locks by hand if necessary.

MACHINERY EQUIPMENT.—The machinery for operating the bridge is very simple. It consists of three sets of gear wheels connecting with each motor and meshing into the straight rack of the operating strut. All of these gears are of cast steel and are in the rough, except that cut gears are used for the first gear engaging the armature shaft pinion and for the main operating pinion. The motion of the bridges is said to be very smooth, and is practically noiseless, the latter being an important point for city bridges.

Each bridge is operated by two 35-HP., 220-volt, direct-current motors, geared to the main cross shaft. The actual power required to open or close the bridge in one minute u[nder] wind conditions is 25 HP. Thus [one] sufficient to operate the bridge sa[fely]. second motor is provided only for e[mer]poses. Each motor is equipped wi[th] solenoid brake which is normally [held] of a spring, and released by [the] There is a hydraulic emergency [brake] driving shaft, operated by a hand [wheel] operator's house. The rail locks a[nd] the bridge are operated by means [of] direct-current motor, and the end [locks] ated by a motor of the same size.

A reinforced-concrete platform [at] the bridge connects the trusses [for] venience of the bridge tender in oili[ng] for the machinery. Access to this [is] by means of a stairway attached [to] ating strut and to the side of the co[un]. The main trunnions are lubricate[d] platform through gas pipe conduit[s] sure grease cups.

OPERATION AND SIGNALS.—[The] bridge carrying the tracks of the Pennsylv[ania] Lines, being remote from the others, is op[erated] from the railway signal tower adjacent to [the] bridge. Power is generated in the same [building] by means of two small dynamos, each [driven] by a kerosene engine. These units are used [to] charge the storage battery, from which [250]-volt current is taken for the operation of [the] bridge. The generating and storage battery [plants] furnish current for the railway company's electric interlocking plant as well as for the operation of the bridge.

The three bridges for the Lake Shore & Michigan Southern Ry. and the Baltimore & Ohio Ry. are operated from one signal tower controlling the tracks of the several railways using the bridges.* The power plant for the operation of the bridges is contained in the same building. This installation is of interest, as provision is made for operating a greater number of drawbridges from one point than has ever been attempted elsewhere. Three-phase alternating current at 440 volts is delivered at the plant by

*This tower provides also for the operation of the third adjacent bridge of the Lake Shore & Michigan Southern Ry. and the bridge of the Chicago, Lake Shore & Eastern Ry. Both of these are of the Scherzer type, as already explained, but will be operated in connection with the Rall type bridges described in this article. The interlocking for the protection of the five bridges as well as the operation of the bridges will be handled from this one tower. The electric interlocking plant is being installed by the General Railway Signal Co.

FIG. 3. DOUBLE-TRACK BASCULE BRIDGE (RALL TYPE); PENNSYLVANIA LINES.
(At the right is shown one of the rollers, with the massive girder in which it is carried.)

a power company. Two 40-ampere mercury arc rectifiers transform the alternating current into direct current, and are used for charging a storage battery of 128 chloride accumulator cells. This may be used to operate the bridges or charge the storage battery under emergency conditions, or may be used in conjunction with the storage battery in operating the bridges.

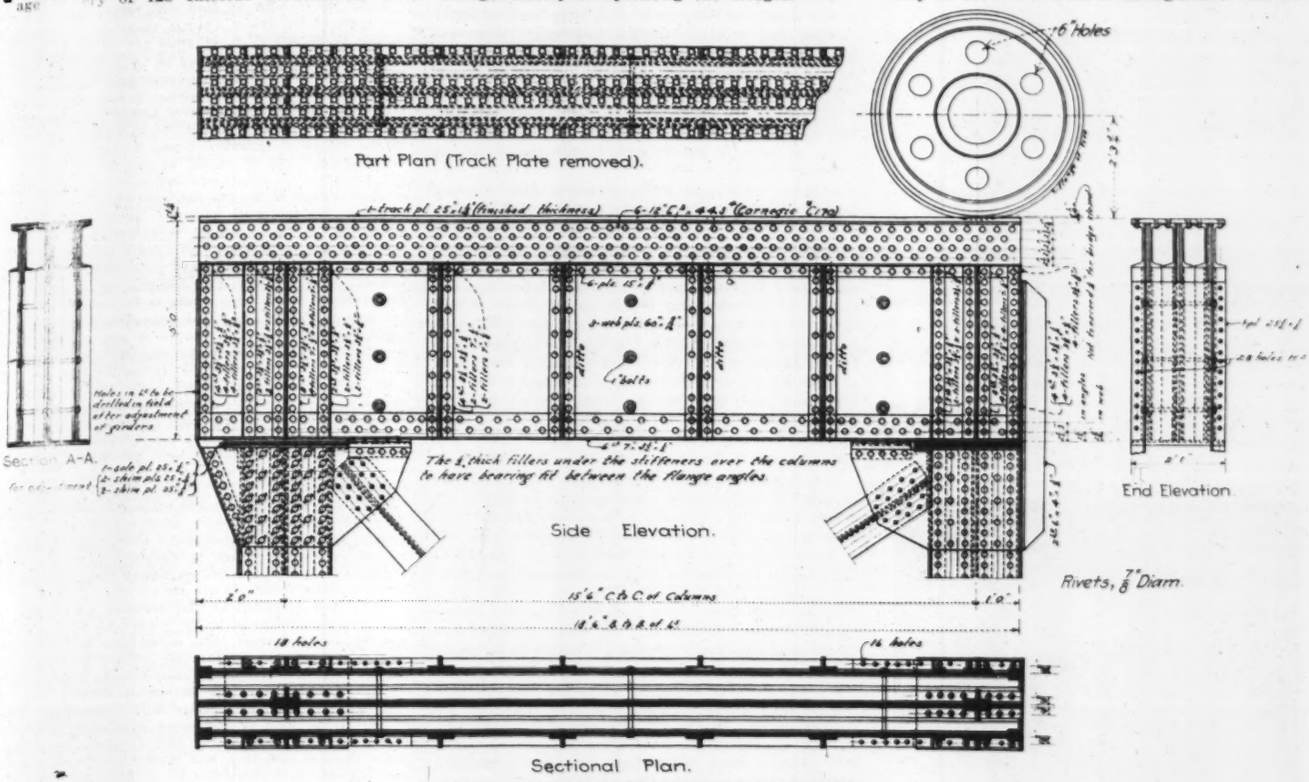


FIG. 4. TRACK GIRDER OF BASCULE BRIDGE.

This battery is used for operating the several bridges and for the electric interlocking and signal system governing the tracks crossing the bridges. In addition, a direct-connected motor generator set of 35 KW. capacity is installed.

The storage batteries are installed in the basement of the power-house. The generating plant and a complete switchboard for its control are on the ground floor. The electric signal machines and the controlling appliances for the bridges are on the second floor, from which all tracks and bridges are in clear view. Each bridge has its own switchboard and controllers, and each board has electric indicators showing the operator the position of all devices on the corresponding bridge.

The several motors on each bridge are electrically interlocked with each other and with the signals governing the approaching tracks. Nothing can be done toward opening any bridge until all signals governing the approach tracks are set at the "stop" position. In closing, the signals cannot be set for a clear track until the bridge is closed and locked and the rail locks are set for the passage of trains.

For the guidance of vessels approaching the bridge, there are two river signal lights (one green and one red) at the extreme end of each bridge on either side. These signals have incandescent electric bulbs installed in independent lanterns, and are so arranged that the red light will show while the bridge is in the closed position and throughout its motion. When it reaches its open (or nearly open) position, the lamp in the red lantern is extinguished and that of the green lantern is lighted by the operation of a gravity mercury switch.

The Strobel Steel Construction Co., of Chicago (as contractor for the superstructures), designed the four Rall bridges, prepared all general and detail plans, and erected the superstructures, including the installation of the machinery. The structural steel was fabricated by the Pennsylvania Steel Co., of Steelton, Pa. The machinery was furnished by Geo. P. Nichols & Bro., of Chicago, who also furnished and installed the electric equipment. The railway companies were represented by the following engineers: Mr. Albert Lucius, M. Am. Soc. C. E. (of New York), as their joint consulting engineer; Mr. J. C. Bland, Engineer of Bridges, Pennsylvania Lines; Mr. B. R. Leffler, Engineer of Bridges, Lake Shore & Michigan Southern Ry., and Mr. J. E. Greiner (and later Mr. W. S. Bouton), Engineer of Bridges, Baltimore & Ohio Ry.

Fig. 3 is a view of the pivoted end of the Pennsylvania Lines bridge, showing one of the rollers and the massive girder in which it is mounted. Fig. 5 shows the two Lake Shore & Michigan Southern Ry. bridges in the open position; in this view the top of the roller may be seen above the middle of the horizontal line of the triangular girder in the left-hand truss.

FIG. 5. TWO DOUBLE-TRACK BASCULE BRIDGES (RALL TYPE); LAKE SHORE & MICHIGAN SOUTHERN RY.

(The top of the roller of the left-hand truss may be seen at the middle of the horizontal line of the triangular plate girder.)

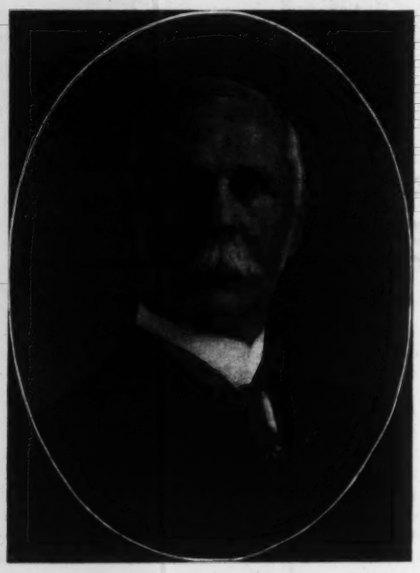
TYPHOID FEVER DEATHS IN CHICAGO for 1908 totaled 338, or at the rate of 15.6 per 100,000. This was 12% below the rate for 1907, about 33% lower than the average for the last ten years, and 91% below the record-breaking figure of 1891, when the appalling rate of 173.8 per 100,000 was recorded. For the nine years since the opening of the drainage canal, the average rate per 100,000 was 21.1, as against 57.7 for the nine years before the canal was opened. According to the bulletin of the Chicago Department of Health for Feb. 20, 1909,

if the pre-channel typhoid rate had prevailed during the last nine years there would have been 10,035 deaths from typhoid fever in that period, or 6,014 more than actually occurred. Figuring on the basis of the legislative value of a human life, this saving represents the sum of $64,140,000 or more than the entire cost of the drainage channel to date.

William McNab: President of the American Railway Engineering and Maintenance-of-Way Association.

The Vice-President of the American Railway Engineering and Maintenance of Way Association for 1908, Mr. Wm. McNab, became the Acting President as a result of the sudden death of the President (the late Walter G. Berg) in May last, and has now been elected President of this Association, in whose affairs he has been active since its organization nine years ago. His professional career (of nearly 40 years) is somewhat unique in that it has been entirely with one corporation, the Grand Trunk Ry. Co., of Canada. The history of his life, therefore, is a story of the development or evolution of that railway from its small estate of 40 years ago to its present extensive system and its important standing in railway affairs.

Wm. McNab was born in Scotland 54 years ago. He is a son of the late Thomas McNab; grandson on his father's side of the late William McNab, Curator and General Superintendent of the Royal Botanic Gardens in Edinburg, and on his mother's side of the late James Haig Cobban, Collector of Customs at Alloa, Scotland. Coming to Montreal with his parents at an early age, he



William McNab

was educated at the McGill Model School and at the Montreal Collegiate School. On graduating from the latter in 1870, he entered the service of the Grand Trunk Ry. Co. as an indentured pupil in the Engineering Department, and has since been connected continuously with that great Canadian railway system.

During this long period of service, Mr. McNab has had charge of the surveys for and the construction of many of the new lines which eventually became part of the system, as well as having been closely identified with the design and superintendence (both in new construction and maintenance) of most of the important works that have been the means of transforming the old Grand Trunk Ry. into its present system. That these works were many and varied in character goes without saying, and the opportunities for gaining experience were neither few nor insignificant on a road which has grown from small things to a system of magnitude and international importance.

Previous to 1875, Mr. McNab was engaged with the then Chief Engineer upon detail matters connected with the works of the International Bridge, then in course of construction across the Niagara River between Buffalo, N. Y., and Fort Erie, Ont.; upon the location and construction of the Lewiston & Auburn Ry., in Maine (including its bridge work); the construction of the Union station and general terminal facilities at Toronto, and the erecting and machine shops at Stratford, Ont. He also superintended the various works connected with the construction of iron structures for the renewal of all the large Howe truss bridges on the railway; the construction of the new train-ferry docks at Point Edward, Ont., and Fort Gratiot, Mich.; and the work of narrowing the old broad gage of 5 ft. 6 ins. (on the older lines) to the standard gage.

Between 1875 and 1885 inclusive, after having passed an examination before the Board of Examiners of the Province of Quebec for the study of land surveying, he was engaged for several years almost exclusively upon Grand Trunk Ry. surveys. During that period he acted as engineer of surveys and levels on upwards of 400 miles of projected revision work. He was engineer of construction of the double-tracking between Scarborough, Ont., and Toronto, Ont., and of the York yard terminals and engine houses; also engineer of location and construction of portions of lines in Michigan and in the provinces of Ontario and Quebec, which lines are now merged into the Grand Trunk Ry. system.

Between 1886 and 1896 inclusive, he had charge of general engineering work and maintenance-of-way, including control of construction of the terminal station at Montreal; the Wellington St subway under the freight and terminal yards at Montreal; the Back Cove drawbridge and approaches at Portland, Me., and the design and construction of masonry and other general structures. From 1896 to 1907 he superintended the drafting room and assisted the Chief Engineer generally on various new works. These latter included the replacing of the historic Victoria single-track iron tubular bridge across the St. Lawrence at Montreal by the present bridge, having double-track steel truss spans. In 1907, Mr. McNab was appointed Principal Assistant Engineer of the whole Grand Trunk Ry. system, 4,645 miles. This position he now holds.

Mr. McNab has had ample opportunities of extensive travel, and the knowledge acquired by such opportunities has been used to advantage. He is a member of the American Society of Civil Engineers, the Canadian Railway Club and the Canadian Society of Civil Engineers. He was a member of the council of this last body in 1903 and 1907, and is at present chairman of its committee on transportation routes. He is a charter member of the American Railway Engineering and Maintenance of Way Association. He was the first vice-chairman of the committee on graduation (afterwards roadway), becoming chairman in 1902. In 1904 he was appointed chairman of a new committee, on economics of railway location. He was elected a Director of the association in 1905, Second Vice-President in 1907, and became First Vice-President in 1908. During this term he succeeded to the office of President made vacant by the death of the late Walter G. Berg. He has now been elected President for the year 1909.

The Regulation of Chicago's Gas Service.

A report has been made to the Committee on Gas, Oil and Electric Light of the Chicago City Council, on a suitable regulation of the gas service of Chicago, by D. C. and W. B. Jackson, engineers, of Chicago and Boston. This report is brief and rather general, but contains the following specific recommendations:

IMPURITIES.—Hydrogen Sulphide; Not more than a trace should at any time be found in the gas.

Total Sulphur; Present practice indicates that the maximum allowable total sulphur should not be greater than 30 grains per 100 cu. ft. of gas, and we believe that for the conditions in the city of Chicago, 20 grains of sulphur per 100 cu. ft. of gas should be the maximum limit.

Ammonia; Present practice indicates that this limit should not be greater than 10 grains of ammonia per 100 cu. ft. of gas, and we believe that 10 grains per 100 cu. ft. would be a suitable limit for Chicago.

ILLUMINATING VALUE OF GAS.—We believe that the illuminating value of the gas in Chica[go] should at no time fall below 22 c. p. when burned at a rate of 5 cu. ft. per hr., as provided in the ex[isting] Chicago ordinance.

HEATING VALUE OF GAS.—We believe that the heating value of the gas in Chicago should not be permitted to fall below 600 B. T. U. gross per cu. ft. of gas.

All results given above are to be understood as applying to 60° F. and 30 ins. barometric pressure.

PRESSURE FLUCTUATIONS.—We believe that the maximum allowable variation of pressure at the inlet of any meter in Chicago should not be greater than 100% of the minimum pressure found at any time at that meter, except that it should be one duty of the chief gas inspector to set a new minimum upon the written request of the gas company when conditions affecting the minimum pressure change due to the growth of the gas system or to development in the art; such changes to be made not oftener than once in six months. We understand that it is impossible at the present time for the gas company to maintain the gas pressure within such limits at all points on their gas supply system. It would, therefore, seem that regulations relating to this feature of gas supply cannot be effective until the requisite changes have been made in the gas distribution system. In the meantime, we believe that the company should, upon the complaint of any consumer, at whose meter there is a greater variation than 100% of the minimum pressure, adjust his gas consuming devices so that the gas service is satisfactory to him, or should provide a local governor to hold the variation in pressure at the meter within the above prescribed limits.

MINIMUM PRESSURE.—The allowable pressure at the inlets of consumers' meters should never become less than a definite amount. Present practice indicates that 1½ ins. of water pressure, at the street level, is a satisfactory minimum limit, and we believe that such a minimum could be a suitable one for the city of Chicago.

MAXIMUM PRESSURE.—Our study of the question of gas pressures leads us to the belief that it is not desirable at the present time to set any hard and fast maximum allowable pressure in Chicago; but, owing to certain conditions heretofore explained, we believe where consumers now have gas consuming devices installed that will not suitably operate with pressures of over 6 ins. at the inlet of the meter (located at the street level) that the gas company should adjust the consuming devices so that they will operate satisfactorily when the pressure rises above 6 ins.

TESTS FOR PRESSURE.—We believe that in addition to the pressure measuring devices in the testing stations there should be at least three seven-day recording pressure gages for each testing district to be located at various points over the district in which a testing plant is situated and the locations to be changed from time to time. Such testing gages to be of the line drawing kind which show the pressure of gas at every instant and each chart to be arranged to show the pressure continuously for seven days.

TESTS FOR THERMAL VALUE AND CANDLE POWER.—We believe that besides the tests to be regularly made in the testing stations for heating power, additional tests should be made from time to time of gas taken at various points in each of the districts, and occasionally tests for candle power should be made as well as for heating power.

COMPLETE ANALYSES OF GAS.—From time to time complete analyses of the gas should be made in each testing station, and whenever tests for calorific value of gas are made at points outside of the stations complete analyses of the gas found at these points should be made.

FREQUENCY OF TESTS.—We believe that tests for the candle power, thermal value, and the presence of hydrogen sulphide, in the gas, should be made daily, excepting Sunday, in each testing station, and the tests for ammonia and sulphur should be made weekly, while the recording charts of the various continuous pressure gages should be changed weekly. The additional tests for thermal value and candle power of gas taken from outside points should be made from time to time as may be found necessary for a complete determination of the quality of gas as supplied throughout the city. Also the complete analyses of the gas should be made with sufficient frequency to properly supplement the other tests.

Rules as above proposed, if carried out by the gas company, will in our opinion, assure a satisfactory gas supply to the City of Chicago, and the operation of the testing stations and other supervisions outlined, when the work is carried out in the above described manner, will give the city all information needed for enforcing the rules.

A BOREHOLE 7,370 FT. DEEP is being drilled near Rybnik, in southwestern Germany, says the "Zeitschrift des Vereines Deutscher Ingenieure." By December, 1908, it had reached a depth of 7,070 ft., with a diameter of 2 ins.

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That the standard of quality of municipal water-supplies is rising is well shown in the course of the interesting article elsewhere in this issue on the operation of the Ludlow intermittent filters, connected with the water-works of Springfield, Mass. These filters were designed to remove or prevent bad odors and tastes in the water during the warmer months of the year. After a year or two of experience with the filters the public has expressed its desire to have the filters opened in the spring and kept open in the autumn, when the water was, relatively speaking, so satisfactory that its slight taste or odor in former years would have caused no comment whatever. The time is rapidly coming when every community will demand water perfectly clear, tasteless and odorless at all times in the year, as well as water free from sewage pollution and its accompanying infectious matter.

A few years hence a privately-owned water-works system in an American city of any size will be a rarity. The census of 1900 showed 54 cities with a population of 70,000 or upwards. Of these, only 10 are to-day dependent upon companies for their water-supply. Of those 10, New Orleans has already virtually changed to public ownership, and San Francisco, Denver and Omaha have been struggling toward that end for some time. At Omaha an arbitration award, placing a valuation on the plant of the private company, has been before the courts for some time, and it is stated that the city will soon vote on a bond issue sufficiently large to cover the highest price which it can be compelled to pay if the decision goes against it. Denver is awaiting a valuation award from a commission of five engineers of national reputation.

At San Francisco the movement for municipal ownership is at a more uncertain stage. The city has no specific authority, as we understand it, to compel the company to sell its works, and is seeking legislation which will clear the way for such action. The new works about to go in operation at New Orleans, which have been built by the city, make up the very serious deficiencies in the works of the private company. The city, we understand, will utilize some, at least, of the distributing mains of the company, but no other portion of the private works. New Orleans, for what reason we will not undertake here to say, seems to afford about the most notable instance which can be brought forward of the failure of a private water company to meet the needs of a city. This failure could be nearly if not quite matched, however, by similar experiences at Syracuse, but at New Orleans there were physical difficulties in the way, far harder to overcome than any existing at Syracuse.

The companies in some of the cities yet under private ownership have given or are now giving such satisfactory service that very likely they will remain undisturbed for some years to come. Sooner or later, however, it seems almost certain that they, too, must surrender to public ownership.

In our discussion of the sea-level project at Panama, in our issue of Feb. 25, we referred to the old French canal from Colon to Bohio, and stated that a large part of this channel had been filled with silt and mud, as we predicted would happen in 1888. We instanced this as a good object lesson of the silting which would take place in any sea-level canal from the tributary streams.

The "Times" of New York City is about the only journal of prominence which still continues the agitation for a sea-level canal. It has recently published several extended articles attacking the lock canal, written by an alleged "eminent engineer" who is too modest to sign his name. The articles bear internal evidence that the writer of them is wholly unfamiliar with conditions as they actually exist on the Isthmus, and is basing his arguments solely on what he has read. It is not worth while to take space here to point out the many gross errors in these articles; but one remark in the "Times" of March 15 deserves a little comment.

Referring to our statement regarding the silting up of this old French canal, this writer contradicts it and says:

> Although this channel has been completely neglected during the entire period of its existence, its sides exhibit little wash, and actual surveys of its bed show that it has silted up but little during that time. Small bars naturally formed at one point where the channel for the Mindi River was cut across the canal, but there has been little silting proper.

In contrast with this statement by this anonymous "eminent engineer," we would place an official record.

In October, 1901, negotiations were in progress between the president of the new Panama Canal Company, M. Hutin, and the Isthmian Canal Commission, with reference to the acquirement by the United States of the company's rights and property on the Isthmus. The company desired to have the United States pay for the work which it had done there, and it created a committee of its own engineers to make a valuation of the work which it had completed. This valuation was published in the Report of the Isthmian Canal Commission of 1899-1901, and we take from it the following statement of the silt accumulations in the old French canal:

> It must be stated that of the amount of excavation done by the old company in the level from Colon to Bohio, and the left side diversion corresponding to that level, an important portion has been filled in by the silt from the Chagres and other streams that invaded that portion of already deepened river beds. The amount of that silt is about 5,000,000 cubic meters.
>
> A similar fact is to be noted in the section from Paraiso to end of canal; an amount of silt of about 2,000,000 cubic meters has partially filled up the excavations of the old company.

Thus the engineers of the French canal company, which was trying to sell its property to the United States and was trying to make the best showing possible, admitted an accumulation of 7,000,000 cu. meters of silt in the old French canal as long ago as 1901. It may reasonably be concluded that the amount of these silt accumulations was not overestimated. This 7,000,000 cu. meters is equivalent to 9,156,000 cu. yards. The "small bars which naturally formed at one point," according to the "eminent engineer" (anonymous) of the "Times" appear to have been quite sizable!

The Canadian Import Duty on Engineers' and Architects' Drawings.

Those familiar with the engineering and architectural work in Canada are aware that our neighbors on the north are now in the midst of a movement somewhat like that through which our own country passed some 70 years ago. Then it was known as the "Know-Nothing Campaign," and its slogan was "America for the Americans"; now the cry over the northern border is "Canada for the Canadians."

It is not our purpose here to comment upon this attitude; our opinions upon it have been plainly expressed in the past; but for the benefit of engineers in the United States who are not fully informed as to the exclusive policies of their Canadian neighbors, we wish to call attention to a portion of the Canadian customs law, a careful reading of which may save some money to the American engineer or architect who has to do with Canadian work:

"Appraiser's Bulletin No. 152" of the Department of Customs of the Dominion of Canada, reads as follows:

ENTRY OF ARCHITECTS' PLANS AND BLUE PRINTS.

1. The rate of duty on drawings, blue prints and building plans is 25% ad valorem under Tariff item 180. Specifications, however, are free as "manuscript," when written or type-written.

2. Special plans of building, or blue prints as substitutes therefor, are to be valued for duty at the charge usually made by the architect for the drawings, without the specifications. This charge may be fixed for duty purposes at 1% of the estimated cost of the building to be erected.

Detailed drawings, or blue prints as substitutes therefor, if imported separately, to be appraised at a valuation of 1% of the estimated cost of such detail.

3. When the building is estimated to cost less than $10,000, the plans or blue prints thereof may be appraised at the usual charges for furnishing same, according to the special circumstances in each case irrespective of the preceding rule (No. 2).

4. Blue prints or copies of building plans may be admitted at the cost of production when duty has been once paid on the original or a copy thereof in Canada under the foregoing rules, upon proof of such payment to the satisfaction of the collector at the port of entry.

5. Blue prints of cars and machinery, being copies of standard designs, may be valued for duty at 75 cts. per lb.

6. Competitive plans brought in for inspection may be entered as for warehouse and inspected under customs supervision, subject to payment of duty within 60 days unless then rejected and ex-warehoused for exportation.

It seems that the enforcement of this law is subject to the "taste and fancy" of the customs officer, and this leads some of our Canadian brethren into astonishing fits of excitement over the laxity of a Government that fails to protect its people. Witness the following report of a committee of the Ontario Association of Architects:

> The Ottawa Chapter has made inquiries at the Customs Department at Ottawa, relative to the duty at present payable on designs or drawings imported into Canada. To say that success, except in a limited way, has crowned the efforts of the Chapter would be misleading, but sufficient has been accomplished to justify and stimulate further effort, both individually and collectively. The Secretary of the Chapter has been actively investigating the evasion of payment of duty on plans, and has been able to bring to the notice of the Department a number of instances where duty was not collected or being evaded, with a result that a very substantial sum has been subsequently collected by the Dominion Government. Similar cases of like success have been reported from other places in the Dominion, but there are still a number of instances where they are ignorant as to whether duty had been collected or not, owing to the non-committal attitude of the officials, who seem to maintain a strict secrecy as to the conduct of their department. * * *
>
> The proper method of valuing imported plans should be finally determined not on the author's estimate, but on the actual tenders received for the work. The absolute necessity for architects in all the large towns and cities to exercise a constant vigilance and to notice and report to the Customs Department every instance of imported plans and attempted evasions of tariff is imperative. It cannot be too strongly urged the need of prompt, united and vigorous action in this matter, in bringing it officially before all sister societies throughout the Dominion, and impressing upon them the necessity for concerted action, in order that every legitimate influence can be brought to bear on the Government to have the tariff effectively enforced.

This Canadian law has been brought into public prominence recently in the case of Toronto's new $800,000 filtration system for its water supply, the plans for which, drawn by Mr. Allen Hazen, of New York City, are now in the hands of the Canadian Customs Department pending an official decision upon the necessity for collecting thereon a $5,000 duty.

The city officials of Toronto, it is fair to presume, selected Mr. Hazen for their work because of his high reputation and wide experience in this branch of engineering, just as they recently called in consultation on their sewage disposal problems Mr. John D. Watson, of Birmingham, England, and Mr. Rudolph Hering, of New York City, just as Mr. A. W. Robinson, of Montreal, is frequently called on for plans and advice by prominent builders of steam shovels and dredges in the United States. In other words, the international competition is not a competition of prices but of quality of service. Assessing a duty on the plans which Mr. Hazen may send to Toronto or which Mr. Robinson may send to New York will not stop those on either side of the border who want first rate engineering talent from securing it wherever it may be found.

The Toronto officials, it is fair to say, are endeavoring to remedy matters to the extent of their ability. The reception their efforts are receiving among Canadian engineers may be judged from the following extracts from comments on the case by "Construction," a "Journal for the Architectural, Engineering and Contracting Interests of Canada":

A highly intelligent argument put forth by Toronto's worthy officials, is that they are not paying Mr. Hazen, the New York engineer, $20,000 for the drawing of the plans, but that this sum is paid him for his ideas. What does any architect or engineer get paid for? They get paid for their ideas, th ir knowledge, and their services. They have draftsmen to make drawings, tracings and blue prints. What measure of protection would these professions get if a duty of 25% were charged only upon the value of the actual labor in preparing plans? The law would be absurd.

But Mr. Rust [the City Engineer] has a scheme. He is going to have the plans redrawn in Toronto. We do not know what ruling the Customs Department will make in this case, nor are we sure whether any distinct ruling, entirely covering such a case, was ever made by the Customs Department at Ottawa, but we do know that in the United States and in other countries where an import duty is levied upon plans, that duty may be collected at any time, even after the work has been completed, if it can be proven to the satisfaction of the Government, that the work was erected after imported plans.

* * * Something should and must be done to stop this perfidious smuggling of plans into this country.

For the information of our Canadian contemporary, we can say authoritatively that the United States does *not* charge an ad valorem duty on foreign engineer's fees when such an engineer brings into this country drawings or designs which represent the outward expression of the mental labor for which that fee was paid. A 20% duty is levied on all drawings, paintings, etc., considered as works of art, and the standard taken is the value of the drawings themselves. The United States tariff law does not attempt to protect the American engineer from the competition of the foreign engineer.

Tariff duties have to do with commercial matters and are out of place in professional work. Even Canada, we presume, would not venture to assess a duty on the written legal opinion which an American lawyer might furnish to a Canadian client, or on the sermon which an American divine might carry across the border to deliver in a Canadian pulpit. We venture to suggest to our contemporaries which assume to represent the engineering profession in Canada that they awake to the idea that engineers have the right to stand on the same plane as the members of other professions.

Rapid Changes in Sewage Purification Methods as Illustrated by the Sewage Works of Sutton, England.

While there might be cited many British municipalities where a greater variety of methods of sewage treatment have been tried during the past twenty years than at Sutton, England, yet the experiences at that place serve remarkably well to illustrate the rapid changes in sewage purification methods which have recently taken place. It was no longer ago than 1891-93 that Sutton established chemical precipitation works for the preliminary treatment and an irrigation area for the final treatment of its sewage. These works were hardly in operation before Mr. W. J. Didbin, then Chemist to the London County Council and a member of the Sutton Town Council, made the suggestions which led to the building of the epochal contact beds at Sutton, in 1896. These beds, which were the first of the many contact beds to be built in all parts of the world, first received sewage with no preliminary treatment whatever except coarse screening. Some people believed that by their aid the sludge problem had been forever settled. Events at Sutton, and almost everywhere else where reliance was placed upon contact beds alone, showed that preliminary treatment of sewage was required. Accordingly, septic tanks were provided at Sutton. When it became necessary to increase the filter-bed area at Sutton, triple contact beds instead of double contact were laid down. The triple contact beds were put in operation in or about 1904, or eight years after the installation of the first contact beds. At the close of 1908, the Sutton authorities fell in line with the recent marked trend in sewage-purification practice, and in order to provide additional capacity installed a percolating filter. This filter, it may be noted, is 80 ft. in diameter, or 5,292 sq. ft. in area, 5½ ft. in depth, has a water-tight floor and is provided with a rotating sprinkler. The filtering material consists first of 2½ ft. of "clinker of large gage," and next of 3 ft. of "clean pan-breeze [coke] of a gage between ¼ and ¾-in." Radial drain tiles are placed beneath the clinker. The capacity of the percolating filter is rated at 240 U. S. gals. per sq. yd. per day, or a total of 134,000 gals., which is at the rate of about 1,160,000 U. S. gals. per acre per day.

Although these changes at Sutton might seem at first thought to indicate that there is nothing certain as yet in sewage purification, yet cost figures submitted at the time the percolating filter was put in operation show that distinct progress has been made. From 1892 to 1896 the annual expenses due to pumping the sewage and treating it by chemical precipitation and on land averaged $4,437 per year. The volume treated is not stated. From 1896 to 1900 the average cost of pumping and of contact bed and land treatment fell to $3,525 per year. The average yearly volume treated in the last-named period was 190,033,200 U. S. gals., thus giving a cost per 1,000,000 gals. of $18.50. In 1901 the total expenses for the year were slightly increased over the average for the four preceding years, but in 1902 they fell off materially, and in 1905 they fell to $2,323 for the treatment of a total of 261,096,000 U. S. gals. of sewage, or $8.90 per 1,000,000 gals. In 1908 the total operating cost was $2,986, but the volume of sewage for that year was not very much larger than for 1905 and the cost per 1,000,000 gals. was raised to $10.72. The percolating filter, it will be remembered, did not go into operation until the close of 1908, but as this is designed to treat only 134,000 U. S. gals. per day, or less than one-fifth of the total volume, it is not to be expected that the percolating filters will have any marked effect on the operating costs. It may be stated here that the population of Sutton is about 18,500, distributed over an area of 1,835 acres. It is also interesting to note that the percolating filter described above cost a total of $3,169, and that an additional sedimentation tank (180,000 U. S. gals. capacity) was provided, at a cost of $646, to accompany the percolating filter.

We cannot refrain from noting that all of the so-called biological sewage-treatment works at Sutton have been carried out, not only without the sanction of the Local Government Board, but also, in their initial stages, with the disapproval of that body. As has often been stated in these columns, loans for nearly all municipal purposes in British municipalities must receive the sanction of the Local Government Board, which by this means has full control of the character of engineering and other public works. [illegible]ase a municipality builds works out of yea[illegible] revenue or proceeds of taxation, it need not [illegible] the Local Government Board for approval, [illegible]ough it is liable to get into trouble with th[illegible]rd in one way or another later on. Sutton [illegible]eded with its contact beds and other sew[illegible]works improvements until 1898 without a[illegible]g to the Local Government Board for a loan[illegible]horization. An application then made brought [illegible]he whole matter of the character of the se[illegible]works installed, whereupon the Board decli[illegible] sanction the loan then proposed, but inform[illegible]tton that they considered the "action of the [illegible]ell in carrying out the experiments without [illegible] approval as open to much objection."

Since the earlier Sutton work[illegible]ere constructed, but subsequent to the inte[illegible] report of the Royal Commission on Sewage [illegible]posal, the Local Government Board has appro[illegible]d so-called biological methods of sewage treatm[illegible] without the usual subsequent application [illegible] effluent to land. The most recent utteran[illegible]s of the Royal Commission on Sewage Disposal seem to open the way for leaving each mun[illegible]pality to choose between contact beds, percolating filters and land treatment, or any desired combination of these, the choice to depend upon local conditions instead of some hard and fast rule laid down years before by a central administrative body.

It seems quite possible that had not the Sutton Council had the courage to go on without the approval of the Local Government Board, the wonderful progress in sewage disposal made since the installation of Mr. Dibdin's first contact bed at Sutton would at least have been materially delayed. The lessons for the increasing number of American central administrative bodies having jurisdiction over plans for sewage and water purification works are too obvious to need further remarks.

LETTERS TO THE EDITOR.

Workmen or Technical Graduates for Construction Superintendents.

Sir: What are the qualifications expected for the position of superintendent of construction or erecting foreman on building construction or other engineering work? Do employers want a journeyman or workman for such positions or do they look to the college man or technical graduate to fill positions of this kind?

"Reader."

—— South Carolina, March 1, 1909.

[In most cases such positions are filled by men whose education has been obtained in the school of hard knocks. If an engineering graduate has executive ability and a practical bent of mind, and is willing to do hard work, he will often do better in the long run to seek positions of this sort than to follow purely professional lines of work.—Ed.]

Effective Driving of Cast Concrete Piles.

Sir: In your issue of Feb. 25, p. 223, there is an article by Mr. Clarence S. Howell, entitled "Straight or Tapered Concrete Piles." With the main purpose of Mr. Howell's article, I have no quarrel as I believe in straight piles, but he makes one statement which I think is misleading and should be corrected. He says:

Probably the most successful method of placing the cast pile is that of first securing the required penetration by driving a shell and then placing therein a cast pile, the space surrounding the pile being filled with grout. It has not, up to this time, been found possible properly to drive the cast pile, except by this method.

In the past three years I have personally supervised the manufacture and driving of about 600 cast concrete piles (reinforced), ranging in length from 10 to 30 ft. All of these piles were cast in molds and when seasoned were driven with ordinary railroad pile drivers, using drop hammers, cushion caps being employed to protect the heads of the piles. Where the driving was in sand a jet was used but most of the piles were driven without the jet. A very small percentage of these piles were shattered in driving, but in every case this was due to the fact that sufficient time had not been allowed for the concrete to season.

To illustrate what cast piles will stand in the way of hard driving, two cases may be mentioned. In the first one the piles were about six weeks old and each

one was ... more than 300 blows with a 2,800-lb. hammer, ... a maximum drop of 12 ft. In the other case some ... roughly seasoned piles 30 ft. long were driven full ... gth into the ground, using a 2,500-lb. hammer. ... the first half of their length they were driven wi... hort blows, while for the last half they were given ... full drop of the hammer. At the finish this was t... gh a distance of 35 ft. About 200 blows were requi... to drive each pile. Only one well seasoned pile ... been broken.

If the d... g is carefully done the only injury to the pile is th... caking off of a few small pieces of concrete from ... e corners of the head. These piles have been used ... supporting track scales and bridge piers and in th... onstruction of concrete pile trestles, and are to-day ... rrying the heaviest railroad loads without settlement ... defect of any kind.

In view ... this experience it cannot be said that cast piles have not been properly driven without the use of a shell.

Yours truly,

L. J. Hotchkiss,

Asst. Bridge Engineer, Chicago, Burlington & Quincy R. R. Co. Chicago, March 4, 1909.

The Effect of Secrecy in Gas Engineering.

Sir: It has always seemed to me peculiar that certain classes of manufacturers endeavor to keep their methods of construction or the design of their machines secret. Especially is this so in the gas profession, and particularly in that branch which has for its object the designing and building of coal gas benches.

The experience of the writer when in Europe some years ago was that the great success which attended the efforts of American manufacturers, who introduced their machinery and plant into European factories was due to the large amount of publicity which they gave to all details of their manufacture. In my own case and that of other engineers who had charge of large works there, I know that it was only this desire to thoroughly show the merits of his machine or plant that induced me, and those other managers, to place the contract with the American company, and I am positive that neither the purchasing company, the contractors, nor the man who had to operate the plant or machine ever suffered anything by those modern methods of selling goods. Ever since I have been working in this country I expected to see similar methods in vogue, but, strange to say, here in the land of their inception they have not been adopted as they have been by Americans abroad.

Take for instance the building of a gas plant. The designs which are submitted are of the crudest description, being merely outlines, and my actual experience proves that it is only with the utmost difficulty that gas engineers can obtain sufficient information to enable them to decide which of the many schemes submitted is likely to prove most economical in working. In other words, the very men who are able to watch daily the results obtained in working certain classes of plant have little or no say in the selection of the design for new plant. It is admitted on all hands that in some parts of the gas manufacturing process, American methods are considerably behind those of Europe, and in the retort house this is particularly so. I fully believe that this reproach would be removed very quickly, if full advantage was taken of the practical experience of superintendents and engineers in gas plants. At the present time such superintendents have only the choice of one or another evil when they purchase a new plant. If on the other hand they were given a full opportunity of examining details of a bench, they could from their experience so modify the same that resulting work would be considerably improved in all directions.

To show that I am not asking other people to do what we ourselves would refrain from doing, I enclose for your inspection some drawings such as I have induced our company to prepare, and these are always at the disposal of anybody interested in new retort house work. At the same time, we do not tie ourselves down to the construction of any standard bench, but are willing to carry out the ideas of any progressive gas engineer.

I think this matter is of sufficient importance to the gas and other allied industries to be fully discussed in the technical press.

Very truly yours,

A. S. B. Little,

Engineer, Gas Works Division,

Evens & Howard Fire Brick Co.

St. Louis, Mo., March 2, 1909.

[The drawings submitted show designs for benches containing four, five and six retorts, prints from the drawings can doubtless be obtained by any interested reader by addressing a request to Mr. Little.—Ed.]

THE LAGUNA DAM, being built by the U. S. Reclamation Service at Yuma, Ariz., has been practically completed, according to a press report dated March 6.

The Ontario 110,000-Volt Power Transmission System.

The latest development in the plans of the Hydro-Electric Commission of the Province of Ontario is the letting of contracts for 300 miles of 110,000-volt transmission line between Niagara Falls and the towns about Toronto, Hamilton, London, St. Thomas and intermediate points. The general layout of the work will be seen from the accompanying figure. Three-phase current will be supplied by the Ontario Power Co., at Niagara Falls, Canada, at 12,000 volts and 25 cycles, and will be stepped up to 110,000 volts for transmission. The present capacity designed for is 40,000 HP.

From Niagara Falls the line runs 50 miles northwest to Dundas, where it divides, one line of 40 miles running to Toronto and two others going in a westerly direction to London. The northern branch is some 120 miles long and the southern is 75 miles. From London there is a 14-mile extension to St. Thomas. It is expected that the line will eventually be extended to Windsor, a distance of some 100 miles, through the towns of Windsor, Walkerville and Sandwhich will have to unite to use the minimum amount of power which will make this possible.

These lines, as shown in the accompanying figure, differ somewhat from those laid out by the Hydro-Electric Commission in the earlier studies, shown in its 1906 report on this district.*

The transmission lines will be of stranded aluminum cable having an equivalent cross-section of 000 B. & S. gage except between Niagara Falls and Dundas, where the cables will have an equivalent cross-section of 0000 B. & S. gage. About 500 tons of aluminum will be required. The cables will be supported from steel towers normally spaced 550 ft. apart. The minimum spacing will be some 100 ft. on curves. The maximum distance will be at the Humber River, where there will be a single span of 1,250 ft. At the Welland Canal, extra high towers will be required to give a clearance of 150 ft. It is stated that there will be some 3,200 towers of an average weight of 2.32 tons each. To secure adequate insulation for this voltage it has been necessary to discard the old familiar petticoated "pin" variety for the newer "multi-link suspension" type. Here a series of flanged and petticoated porcelain disks, held together by separated cable links, suspend the transmission line from the steel work. This construction was described in Engineering News, Aug. 8, 1907.

MAP SHOWING THE LOCATION OF THE ONTARIO POWER TRANSMISSION SYSTEM.

The general contract for the construction of the line described has been let to Mr. F. H. Guigan, of Toronto, and contracts have been sublet as follows: to the Canadian Bridge Co., of Walkerville, for steel work; to the Northern Aluminum Co., of Shawinigan Falls, for transmission cables; to the Niagara & Ontario Construction Co., of Toronto, for other materials and for the actual work of erection. Muralt & Co., of New York and Toronto, have been retained as supervising engineers, and Mr. C. L. De Muralt will personally take charge of the erection work.

*A few power costs, as estimated by the Hydro-Electric Commission, for this district were given in an abstract of its report in Engineering News, Dec. 19, 1907.

Operation of the Intermittent Water Filters at the Ludlow Reservoir, Springfield, Mass.

Over thirty years ago, long before there was any scientific knowledge of the causes of bad tastes and odors in stored surface waters, the city of Springfield, Mass., made no end of trouble for itself by constructing a large, shallow storage reservoir which had for a bottom from 1 to 46.5 ft. of black muck—as it subsequently learned. After years of agitation over a new supply and over methods of treating the Ludlow water, it was finally decided to build a temporary filter plant, for use during the introduction of water from the Westfield Little River, now well under way. In 1905, Mr. Allen Hazen, M. Am. Soc. C. E., was engaged to design such a plant. Construction was carried out under the direction of Mr. E. E. Lochridge, Assoc. M. Am. Soc. C. E., now Chief Engineer of the Springfield Water Department. The filters were put in operation in July, 1906, and gave good results that year. The next year, Mr. Carroll F. Story, now Assistant Chief Engineer of the water-works of Springfield, took charge of the plant.

At a meeting of the New England Water-Works Association, on March 10, Mr. Story outlined the history of the Ludlow reservoir, described the filter plant briefly, and reviewed the operations of the filters in some detail.*

Mr. Story's description of the filters has been slightly condensed to read as follows:

Description of the Filters and Aerating Devices.

Plans were hurried and the contract was let in the fall of 1905 for the leveling off of the peninsula [at the Ludlow reservoir] so that the work would be finished by spring in time for the construction of the filter proper which was to go upon this area. No concrete floor or special precaution of any kind against the loss of water was used. Upon the surface thus leveled and which was fairly compact, due to the fact that the filling had been done into a depth of from 3 to 14 ft. of water and had been subject to the freezing and thawing of the winter weather followed by spring, the 6 and 8-in. tile underdrains were laid, with open joints. Openings of ¾-in. were left every 2 ft., and the lines of tile were 12½ ft. apart. These underdrains all came into the central drain, which was of concrete. The central drain divided the filters into two sections, two one-acre beds being on each side. Above the underdrains were laid layers of gravel, which was washed from the bank sand. This was the only washing and screening which was done for the building of the filters. On top of the gravel was spread 5 ft. of sand from the bank, the sand being placed in the filters after an analysis of each carload, the aim being to keep the effective size above .30 mm.

Excavation was carried on by means of a steam clamshell bucket, which loaded a train of ten cars, each holding 3½ cu. yds. As soon as a train load was filled the contents of the different cars were analyzed. If the sand in any car was found unsuitable, it was placed in the embankments, otherwise it was used in the filters.

In the center of the four beds was located the aerator, which is one of the novel and essential features of the plant as constructed. The end of the 30-in. pipe, which leads from the pump, discharges into a concrete basin or aerator 30 ft. in diameter, built of concrete. Surrounding this basin is a concrete apron and then a paving of large stones so that the entire diameter of the aerating system is 60 ft. The aerator is so arranged that the water can be discharged into any combination of the four beds that may be desired. It is customary in operation to use three out of the four acres, having the other out to be cleaned. The beds are cleaned in rotation. The capacity of the pump is such that 16 hours operation supplies the amount of water necessary, the operation thus becoming intermittent like a sewage filter.

The essential features of filtration are the central aerator, the intermittent operation of the filters themselves, and the aeration which follows after filtration by water dropping from the small drains into the large

*The full paper, with discussion, will appear in the Journal of the New England Water Works Association.

drain, which is 56 ins. high and 30 ins. in width, inside dimensions, and from the wooden flume which leads from the large drain into the water of the basin below.

The aeration and intermittent action of the filters are undoubtedly the two features which lead to the successful filtration of Ludlow water. In the experiments of the State Board of Health it was found during the worst periods that filters which ran at a high rate allowed anabaena to pass through them, and that those which worked at a low rate were utterly unable to take care of the water, as there was so little oxygen present during the bad stages of the reservoir water that it was entirely removed during the process of filtration. A water resulted that was utterly unfit for use.

Operation of the Plant.

YEAR 1906.—The plant was put in operation in July, 1906. It gave satisfaction that summer, but the natural water was in much better condition than in other years.

YEAR 1907.—In May of this year Mr. Story assumed charge. His account of the operations of the plant from that time to the close of the season of 1908 has been condensed as follows:

About the first of June, when three of the beds had been brought to grade, and the other had been almost finished, it was decided to start up the filters, although the water in the reservoir was still pretty good. The filters were started on a Wednesday and by Friday night all four beds were filled to the top and were barely taking care of the amount of water thrown by the pump. I saw that some action would have to be taken the following morning and ordered the men to report early. Upon going out on the filters the next morning I found that three of the four beds still had water on them, although it was eight hours since the pump had ceased to work. The odor about the beds was so strongly fishy as to be oppressive, and the men complained of it a number of times during the morning. Getting all the boots that I could in the neighborhood I put the men into the filters in order to rake the water down. Then the beds were allowed to stand in the sun and bake until they had dried out thoroughly. They were then given a good raking and the pump was started up. They worked better after this treatment but I saw that it would be necessary to start at once on the work of scraping, although the filters had been in operation only four days.

To say that I was discouraged at the outlook would be putting it mildly. I had been sent to the filters under orders not to rake the beds under any condition, because the State Board of Health had not had very good luck with this form of treatment, and here at the very start I found that I was forced to resort to it. I went into the laboratory after the filters were running to make a microscopical analysis of the water and found that it contained a large amount of uroglena and asterionella. For the next three weeks the water continued to be almost as bad, the numbers of asterionella varying from about 2,000 to 7,100 standard units per c. c. Operation grew less difficult as the asterionella gradually disappeared.

In this connection I may say that my experience with asterionella has not been a pleasant one. The filters will remove the taste and odor very satisfactorily, but the organism seems to completely cement the top layer of the sand so that no water is able to pass through. I have removed solid chunks of sand 6 ins. sq. and ½-in. thick which were cemented hard enough so that they still held together weeks afterwards on the shelf of the laboratory. Raking seems to be the only treatment which will keep the beds going during this trouble. I found that a raking which followed a thorough drying out of the bed in the sunlight was fully as satisfactory as scraping off the dirty sand, both as to the quality of the water and as to the ease with which it passed through the sand.

There was very little anabaena present during the first two weeks, but the organism multiplied rapidly during the last part of June. The filters stopped from an epidemic of asterionella right into one of anabaena, but we were fortunate enough to have them working well by that time. The water was very dirty indeed, but the period of the filters was not very short. The anabaena epidemic culminated on July 3, with a count of over 12,000 standard units per c. c. On that date the color of the water was almost doubled, iron jumped from 0.5 part per million to over 1 part per million, CO_2 disappeared entirely from the reservoir water and dissolved oxygen dropped to a much lower figure. This will give some idea of how extreme the fermentation was. The weather had been still and hot for a week and conditions were just right for the fermentation which took place. Filtration on the day in question was difficult, due to the large amount of organic matter in the water, a bed that had just been cleaned filling to the top. Matters eased up considerably the following day, although the effect of fermentation was still apparent. It was several days before CO_2 was again present in the reservoir and the dissolved oxygen dropped to a low figure, where it remained for the rest of the month. Many dead fish were found about the reservoir during this period. Anabaena died out rapidly and had disappeared quite largely in three days. The numbers which had been present for the two weeks preceding had averaged well in excess of 2,500 standard units per c. c.

The water during the epidemic of anabaena, strange as it may seem is much easier to handle than the water afterwards. Reservoir water which had been undrinkable on a number of days was filtered so satisfactorily that it contained almost no taste or odor perceptible even to an analyst, when it dropped from the end of the effluent flume. It was much improved in all respects chemically. Half the color, almost all of the iron, and a large part of the ammonia being removed. But after an epidemic has ceased and the water is full of the oil, which is present during the life of the organism, and of organic matter, due to the death of the organisms, operation becomes more difficult. The taste and odor, although well removed, are not removed quite as completely as during the other stage. It is necessary to give the plant much closer attention in order to secure good water. The period of the bed becomes much shorter and the dirty layer on top is both thicker and blacker. If scrapings are made frequently enough filtration will be very satisfactory. If this is not done the rate of filtration becomes slower and the same conditions will tend to manifest themselves that the State Board of Health found. Slow filtration during this period means a large removal of oxygen and a much poorer water. I watched conditions very closely and always tried to secure a water from the underdrains before the after-aeration which would be high in oxygen. If I found a bed was giving a water low in oxygen I hurried up the scrapings so as to clean this bed as quickly as possible. By taking this precaution I was successful in obtaining a water that was always practically free from taste and odor.

About the middle of July the filters began to work very poorly from a mechanical standpoint. The filtered water continued to be good, however. Although the beds were not dirty it seemed to be hard to get water through them, and we began to hunt for the cause. I started to enlarge the furrows provided to distribute the water over one of the beds and in doing so discovered the true state of affairs. Beneath the new sand which we had placed in the spring was a thick dirty layer of sand at the top of the old bed. This was due to the dirt which had gone through the new sand. The beds were in pretty bad shape due to this sub-surface clogging. I gave the filter which I was then cleaning a thorough overhauling, removing all of the new sand where it was not very deep and the dirty layer on top of the old. In places where the new sand was deep, I removed as much of it as I could by shoveling the sand to one side and taking the dirt out. I then refurrowed the bed and spaded the new sand thoroughly into the old at all points where I had been able to remove the sub-surface dirt. The bed worked much better after this treatment and I gave each one of the other three the same treatment when I came to it on the regular round of scrapings. It was impossible, however, to remove all of the sub-surface dirt, as there was not time to go beneath the thickest portions of new sand. At the end of the year, however, all of the sand placed at the beginning of the year was removed. After this treatment the filters worked easily, giving at all times a water that was fully as satisfactory as any one could wish for.

During August and September the reservoir became very low. There were several minor fermentations of the water with their attendant increase in color and in iron and the accompanying loss of dissolved oxygen. During these times the number of anabaena would rise to several thousand standard units per c. c. for a day or two and would then drop back to a value in the hundreds. Filtration in each case was a little more difficult for several days, but conditions would then go back to the normal. Due to the thorough fermentation which the water had had filtration was very active and the removal of color, iron and ammonia was very high. It may be of interest to state in this connection that during July, August and most of September an average of over 50% of color removal was obtained. This was in contrast with the 25 to 30% that may be expected from an ordinary filter receiving fresh brook or river water of the kind that we have in New England.

Toward the latter end of September the character of the water changed materially. The fall was a very wet one and the reservoir filled rapidly to the high-water mark. The result of the fresh water was apparent immediately as much less color was removed by filtration. Operation during the fall was more or less difficult at all times due to the character of the water and to the frequent heavy rains. There was a distinct epidemic of coelosphaerium which lasted throughout the entire fall, there being present at times as high as 600 and 700 colonies per c. c. of reservoir water. The odor of the water was very grassy and quite disagreeable, but the filtered water throughout was of a satisfactory quality.

I have mentioned the fact that rains made operation difficult, but it may not appear quite clear why this should be so without further explanation. A hard rain coming on a bed which was being cl[illegible] seemed to float the dirt from the windrows and co[illegible] the entire surface with a very black layer. It[illegible] necessary to scrape a part of the bed the s[illegible] time as it seemed to be impossible to get water t[illegible] without this work. In addition to the re-dirtyin[illegible] bed there was also a hardening action and the t[illegible] of sand was sometimes so hard that it was im[illegible] to make much of an impression on it with you[illegible] It was so hard, in fact, that a heavy iron rak[illegible] with all of a man's strength failed utterly to br[illegible] the top. After one or two experiences of this k[illegible] watched the weather pretty closely and tried not[illegible] e a bed off for cleaning at a time when rain seem[illegible]

The filter was finally closed down about[illegible] time, as the reservoir water by that time[illegible] satisfactory enough without filtration. The pe[illegible] however. had become so well educated to the filter[illegible] er that they noticed the difference at once. The[illegible] was so much higher that we received a good man[illegible] nests to keep the filter operating longer. In the[illegible] days the citizens would have considered that t[illegible] were receiving a very satisfactory water.

After pumping had ceased the beds we[illegible] thoroughly scraped by removing the stained sand from the top. The scraping was heavy in places due to the fact that there was still some sub-surface clogging left which we had been unable to remove during the regular scrapings, and this was entirely removed. Owing to the experience which we had had in this connection, it was decided to put no more clean sand on the beds during the rest of the time that the filters would be used, as they had originally been constructed with 5 ft. of sand and not more than 3 ft. is really necessary. But two more seasons were left for the filters before the Little River supply would be finished, and there was enough sand left to finish out this period.

YEAR 1908.—A start was made on filtration about the middle of May, but we were again unlucky enough to run into asterionella almost the first thing. The experience of the year before was exactly repeated. At the end of two or three days' run the filters were all full and it became necessary to resort to raking. I adopted a regular system of raking the beds and in this way succeeded in running the plant with much less worry and trouble than was possible the preceding season. The number of asterionella per c. c. ran well into the thousands for several weeks, with a maximum of 7,200 and the organisms did not entirely disappear until the middle of June.

After the disappearance of asterionella the filters ran better, probably, than they had during any other period during the preceding seasons. For most of June and a part of July so little work on the beds was necessary that it was hard to find enough to do to keep the men busy, although during a part of the time there was considerable anabaena in the reservoir water. The epidemic was not of as long duration as was the one of the preceding season and was not as severe.

Later in the summer coelsphaerium put in its appearance, although not in very high numbers. The water was fairly dirty, but pretty easily handled, and the filters went without very much attention other than an occasional scraping until about the first of September. During this time the reservoir was steadily dropping and the experience of the preceding summer in the removal of color and iron was repeated. The filters were, if anything, even more efficient, and an average of over 55% of color removal was obtained for the months of July, August, September and October.

Owing to a continuation of the long dry spell which made the past year famous, the reservoir dropped steadily throughout the rest of the year. During the latter part of September, all of October and the first part of November operation of the filters was more or less difficult. This was due probably to a combination of causes. The water in the reservoir was as dirty as it had been at any time for several years. Anabaena, coelosphaerium, and asterionella were all present in rather large quantities and the water had a disagreeable taste and odor. The second factor was the low stage of the reservoir. [This interfered with the operation of the pump, and made longer hours of pumping necessary.]

The long hours of pumping destroyed to a certain extent the intermittent action of the beds, as a filter would fail to uncover in the four hours which the pump was shut down unless it was fairly clean. This fact rendered raking difficult as too much time was lost in raking down the water to allow the bed to dry out properly. Even with a large force of men the beds became very dirty during the last part of the period. Notwithstanding the severe conditions under which the filters were operating the water at all times was of a good quality, probably as good as had been secured during the rest of the year.

Finally early in November the reservoir reached the stage below which it was impossible to operate the pump any longer.

The effect of stopping the filters was noticed very quickly in the city and complaint was very generally made as to the quality of the water. The water was really extremely objectionable and dealers in spring

water did not [illegible] giving business until the coming of cold weather. The people were told that the water was no worse than that which they had used in a good many preceding years, but it was hard to make any one believe the statement. The use of good water for three years had educated the people of Springfield to the advantage of a good supply and satisfaction is generally felt in the city that the completion of the Little River supply is now at hand.

RAKING AND SCRAPING.—Now that I have covered in a general way the experience which we have had during several seasons, I will describe the process of raking and scraping. After a bed had been in use for a few days it is shut off at night and left off the following morning until it has thoroughly dried in the sun. Then the men are sent onto it with heavy, long pointed iron garden rakes and they give the top a thorough raking. This breaks up the coating into a fine powder and opens the pores of the sand. A bed thus treated delivers as satisfactory a water as a bed which has just been cleaned, and works about as well. The dirt in the water does not seem to penetrate very much deeper on account of this treatment, but it does make the scrapings somewhat heavier and I was always careful not to use this method too frequently. During the period that anabaena was in the water I used it very little, as I always kept in mind the experience of the State Board of Health. It was extremely efficient, however, during the time that asterionella was prevalent and during periods in which there were few organisms in the water. I tried not to have more than one or two rakings before scraping, but during the first fall, when we had so much rain, this was not always possible. The scrapings then became very heavy and the cost of operation may have been even increased by this process. It could not be helped, however, and the running of the beds at all during that time was probably due to raking.

The process of scraping is different from that in use in other places, in that a hoe is used instead of a wide shovel. The use of a shovel was found impracticable, on account of the large number of stones in the sand. A much thinner layer is removed and the work is done more easily with the hoe than with the shovel. The dirty sand is collected in long rows and is wheeled from the beds by wheelbarrows, being wasted over the bank into the reservoir. It will be easy to understand that this method of scraping is much more costly than in a filter where there are mechanical devices for moving the dirty sand. This is the only method justifiable in a plant of this kind where it is desired to purify the water as fully as possible with a small outlay of money. After the scraping is completed the surface of the bed is very thoroughly raked and smoothed over with heavy rakes. This raking is more thorough and is much harder than that given to a bed between the period of scrapings.

It is a little hard to say just what the period of a bed is, as the time varies so greatly with the quality of the water. I have seen a bed operate for almost three weeks without even a raking. On the other hand, at the end of four days scraping has been necessary. These are probably about the two extremes, and ordinarily they will run about ten days, between scrapings, with a raking in the middle of this period.

OPERATING COST.—With the three years of operation of the Ludlow filter it is possible to get something on the cost per million gallons furnished to the city. The average [approximate] figure for three years shows a cost of $5.73 per million gallons of water delivered to the city exclusive of interest and depreciation on the investment. As the entire construction cost of the four acres of filters was $50,724, the interest on this amount does not add materially to the figure. It is a little hard to tell just what depreciation should be figured, as the plant is only a temporary one. When the filters are brought back to grade the plant will be practically as good as new. This will probably be done, as the supply is to be held against possible use in the future. After the cost of this work is known more reliable figures can be obtained. Even if the plant should be considered wiped out at the end of four years it would not bring the cost of filtration per million gallons very much in excess of that of some other places, and if a reasonable rate is taken the cost will compare very favorably with that of other filters. At any rate, the investment has certainly been a very wise one.

THE USEFUL ARTS AND SCIENCE DEPARTMENT of the Public Library of the District of Columbia (See Engineering Literature Supplement, Dec. 12, 1907) has been well patronized since it was opened in the latter part of 1907, according to the annual report of the library for the last fiscal year. The room accommodates about 50 readers, and "contains reference and circulating books and magazines in the fields of engineering, the trades, agriculture, printing and binding and the other handicrafts, business and the useful arts generally." The report says that "one of the most useful features of the department" is its collection of about 2,500 trade catalogs. Additions to this collection are solicited.

The Isthmian Canal.*

By LIEUT.-COL. GEO. W. GOETHALS,† U. S. A.

On June 29, 1906, Congress provided that a lock type of canal be constructed across the Isthmus of Panama, of the general type proposed by the minority of the Board of Consulting Engineers. As originally proposed, the plan consisted of a practically straight channel 500 ft. wide, 41 ft. deep from deep water in the Caribbean to Gatun, where an ascent to the 85-ft. level was made by three locks in flight. The level is maintained by a dam approximately 7,700 ft. long, one-half mile wide at the base, 100 ft. wide at the top, constructed to 135 ft. above mean tide. The lake formed by this dam, 171 sq. miles in extent, carried navigation to Pedro Miguel, where a lock of 30 ft. lift carried the vessel down to a lake 55 ft. above mean tide, extending to Sosa Hill, where two locks overcame the difference of level between the lake surface and the Pacific. Of the total distance from Gatun to Sosa Hill, 19.08 miles, had a channel 1,000 ft. at the bottom, and there was a minimum channel for 4½ miles through Culebra of 200 ft. at the bottom. The balance of the distance varied in width to 800 ft., the larger portion of the entire canal being not less than 500 ft. The depth of water was fixed at 45 ft. The lake assured a perfect control of the Chagres River.

Certain changes have been made in the original project, the most important being the withdrawal of the locks from Sosa to Miraflores, which was recommended and adopted in December, 1907. This resulted in a change in the direction of the channel in Panama Bay. A breakwater is being constructed from Sosa to Naos Island which, by cutting off the silt-bearing cross current, which has always been troublesome, protects the channel against silting.

A second change is the widening of the 4½ miles of Culebra cut to a width of 300 ft. at the bottom. This was done by executive order and was not made on the recommendation of the commission.

A third change is the location of the breakwaters in Colon Harbor. The necessity for these breakwaters was made apparent in the latter part of January, when a storm of some magnitude seriously interfered with shipping. As originally proposed for both the sea level and lock types, the breakwaters were parallel to the axis of the channel excavated in Limon Bay. If so constructed, sufficient area would not be given to dissipate the waves entering head on into the channel, and they would not afford much, if any, protection to shipping. These breakwaters are to be built out from Manzanillo Island and Toro Point, so as to give a sheltered anchorage, and also an opportunity for such expansion to the waves as to break them up.

A fourth change is in the dimensions of the locks. As proposed by the minority they were 900 ft. by 95 ft., usable lengths and widths. These dimensions were subsequently changed by the commission at the instigation of the President to dimensions 100 ft. wide and 1,000 ft. long. The width was again increased to 110 ft. on the recommendation of the General Board of the Navy, so as to accommodate any possible increase in beam of future battleships.

The Gatun dam is to consist of two piles of rock 1,200 ft. apart and carried up to 60 ft. above mean tide. The space between them and up to the required height is to be filled by selected material deposited in place by the hydraulic process. During the construction of the north side of the south rock pile a slip occurred in November last at the crossing of the French Canal. This was the fifth slip that had occurred at this point, the rock settling to some extent, but generally slipping sidewise until the angle of repose was reached. In this connection it is to be noted that the silt deposits in the channel had not been removed. This slip would probably have passed unnoticed, as did the former ones, but for the fact that at the time a flood in the Chagres River had attained such proportions as to cover a portion of the Panama Railroad tracks just south of Gatun. A newspaper correspondent, going from Colon to Panama, saw his opportunity for a sensational story. He attributed the flood to the dropping of the Gatun dam into the subterranean lake under the dam and locks, which another faker had previously discovered, and the news of the destruction of the Gatun dam was cabled to the States!

The slip did not affect the south slope or side of the rock pile. It was entirely local and did not in any way interfere with the work. It would not have occurred had steps been taken during construction to give the proper slope to the rock pile, but economy of time and money did not warrant such precaution. As stated by one of the engineering publications, "We can state from actual personal examination that this incident has absolutely no engineering significance."

As a result, however, the public is told that dire disaster will follow the undertaking unless the present plans are abandoned and the "Straits of Panama" constructed, that is a sea-level canal across the Isthmus 500 to 600 ft. wide. To accomplish this, however, a lock canal must be built first, and subsequently widened and deepened until the ideal is reached. There are no data available for such a canal. With mountains instead of hills to be removed, estimates are, of course, impossible; so the most optimistic figures, suitable alone to the ideal, are offered as a bait.

Both the majority and minority of the Board of Consulting Engineers considered Gatun a suitable location for a dam; the former adopted it for the typical lock canal used for comparison with the sea-level canal, the latter for the 85-ft. summit-level canal. The majority, however, feared the existence of an underground flow in case of the higher dam, but investigations have failed to disclose any. The great mass of underlying material is not sandy and gravelly deposits as was supposed, but a mixture of these materials so firmly cemented together with clay as to make the strata in which they occur impervious to water.

I venture the statement, without fear of contradiction, that the site of no public or private work of any kind has received such a thorough and exhaustive examination and investigation as the foundation of the dam and locks at Gatun. There is no longer a doubt concerning any of the underlying strata; neither the impermeability, nor the ability of the foundations to bear the loads that will be brought upon them, can be questioned if the data be carefully and impartially examined. The investigations fail to disclose any water-bearing strata or the existence of that underground stream with a discharge equal to the Chagres River itself, which was recently asserted as a fact on the floor of the Senate.

In this connection the statement is also made that the change in the location of the locks at the Pacific end was due to our demonstrated inability to construct the dams, and that as the foundation at Gatun is of the same material, it necessarily followed that the Gatun dam is also impossible of accomplishment.

The majority of the Board of Consulting Engineers of 1906 in its report stated that:

> The dam at La Boca, between San Juan Point and the Sosa Hill, unless carried down to bed rock at that location, would be placed upon a far worse foundation than that proposed at Gatun or Mindi. The La Boca site is one covered by an ooze of mud or silt, with some sandy material overlying the rock. * * * Unless some feature equivalent to that of a heavy masonry core characterized the design of the dam at this point, or unless a resort be made to dredging down to bed rock or near to it, and refilling with suitable material, or an earth dam at this location be made very massive, it would be in grave danger of being pushed bodily out of place by the pressure due to the head of water in the reservoir.

We found the material in the foundations of these dams not only worse than at Gatun, but in nowise comparable. In the former a covering of ooze and silt, in the latter firm ground with a few soft or marshy spots.

I know that the La Boca dams could be built to safely withstand the heads of water in the resulting lake by adopting either the method of dredging out the ooze or by giving massive dimensions to the superimposed structure. The engineering committee and the majority of the commission preferred the former method. In either case the cost would exceed the original estimates, and in addition it is a military blunder to push the locks to and beyond the proper line of defense, especially when the canal is a military necessity to this country. That the dams could be built is evidenced by the fact that the west toe of the Soso-Corozal dam was carried across the valley on the ooze as an embankment for a railroad to be utilized in transporting stone for the Pacific locks. The charge, therefore, that the dams could not be constructed is not true, and the analogy at Gatun does not follow. Nor is there any truth in the statement that the military necessity was an afterthought as has been insinuated.

I visited the Isthmus in 1905 with a committee of the Board of National Coast Defenses, with which I was associated at that time, for a study of the defenses of the canal. When the location of the locks at the Pacific end was fixed, I was directed to call the Secretary of War's attention to the military necessity of withdrawing the locks to the interior. This I did, with the result that in forwarding the report of the Board of Consulting Engineers to the President he calls attention to the fact as follows:

> The great objection to the locks at Sosa Hill is the possibility of their destruction by the fire from an enemy's ship. If, as has been suggested to me by officers of this department entitled to speak with authority on military subjects, these locks may be located against and behind Sosa Hill in such a way as to use the hill as a protection against such fire, then economy would lead to the retention of this lake. * * * If, however, Sosa Hill will not afford a site with such protection, then it seems to me wiser to place the locks at Miraflores.

In forwarding the report to Congress, the President called attention to the change recommended by the Secretary of War in the location of the locks on the Pacific side. The so-called afterthought appears, therefore, as a conclusion reached long before I had any connection with the work.

Discredit is also thrown on the Gatun dam because there has been a desire to reduce the height from 135 to 105 ft. The original height was arbitrarily fixed to secure an excess of weight, so as to fully compress the underlying material supposed to be largely silt deposited by the river. Subsequent investigations show that the

*From a paper read on March 16 before the Manufacturers' Association of Chicago.

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supposed compressibility does not exist; that a marine, not a river deposit is encountered. The greater the height of the dam, the greater the difficulty of constructing the upper portion, and the greater the cost, both in time and money. Why then go to the expense of the extra height of the dam, and what is to be gained thereby?

Much also has been made of the fact that in the testimony before one of the congressional committees mention was made of securing the stability of the superstructure by balancing the dam on the underlying material. Naturally the testimony is read and discussed in such a way as to leave the impression that the entire dam is to be so constructed. The ground to be covered by the dam is crossed by three water courses, the Chagres River, the French Canal, and the West Diversion, and between these streams the ground is undulating, Spillway Hill reaching a height of 110 ft. above sea level. It is not remarkable or unprecedented that there should be depressions which undrained become soft with the excessive rainfall. Except for these the ground is firm. It is in the crossing of these soft spots that slips have occurred and are liable to occur, and to which the balancing method referred. They are relatively small in extent and when drained or filled cause no trouble, as experience at the La Boca embankment clearly proves.

In the sea-level type offered in lieu of the lock type already described, the Chagres River would be controlled by a masonry dam across the valley at Gamboa 4,500 ft. long, 750 ft. of which is subject to a pressure due to a head of 170 ft. during the extreme flood stages of the river. Sluice gates are proposed for discharging the river into the canal. The difference in tides is overcome by means of a lock on the Pacific side in the vicinity of Sosa Hill. While provisions are made for damming or diverting some of the streams that would otherwise enter the canal prism, not less than 22 flow directly into the canal, with no provision to control the currents or check the deposits of material carried by them during flood stages.

The prism of the sea-level canal was to have a bottom width of 150 ft. through the earth sections, or for nearly one-half its length, and a 200-ft. bottom width through the rock sections. Nineteen miles of the length was made up of curves so that the proposed sea-level canal would be not a wide, straight, and open channel, connecting the two oceans, but a narrow tortuous ditch, with varying currents of unknown strength, impeded by a lock, and threatened by a dam resisting a pressure due to a head twice as great as that at Gatun.

To be sure, the partisans of the sea-level type are now proposing to eliminate both the Gamboa dam and the tidal lock by making the channel so wide as to reduce the currents that result from the discharge of the Chagres and the difference in tides, but then fail to explain how they purpose to control or divert the Chagres, the bed of which will be 50 ft. above the water surface of the canal at the juncture. As data is not available for preparing accurate estimates for even such a sea-level type as was originally offered, neither they nor any one else can offer any figures as to time and cost for the construction of such a canal as they now advocate.

In any comparison, therefore, we must confine our attention to the lock type as now building, and a sea-level canal as offered by the board of engineers, and not by the idealist.

So far as the two prisms are concerned, for ease and safety of navigation the lock type is better because of the greater widths of channels, fewer and easier curves, and freedom from objectionable and troublesome currents, both from the Chagres and its tributaries. This must be admitted by all; but the exponents of the sea-level type concentrate their attention on the obstructions and dangers that the locks constitute in the lock type, and also on the dangers that will result from the failure of the Gatun dam, forgetting that at least equally great disaster must follow the failure of the Gamboa dam. The lock in the sea-level canal is not mentioned, probably because the danger is not so great, since there is but one.

Experience shows that the risks to ships in narrow waterways are material and important. In such a channel as the original Suez Canal the delays and losses to commerce were great, and the danger to ships considerable; although the benefit of the widening is striking, this is true even now.

It is well known that the narrow channels connecting the Great Lakes have been obstructed repeatedly by vessels aground or wrecked in such a manner as to block traffic. Even in the entrances to our seaports there is a frequency of accidents, which illustrate the difficulties encountered in navigating narrow and tortuous channels.

Accidents in locks have been relatively few, and none of a serious nature have occurred at the St. Marys Falls Canal during 54 years of its use. The risks to ships in such a narrow waterway, as proposed for the sea-level canal at Panama, far outweigh all hazards in the proposed lock canal, provided the latter is built so as to minimize the chance of accident at the locks. This is met by providing every possible safety device, by building the locks in duplicate and by the installation of a system by which the vessels will be controlled by powerful electric machinery on the lock walls, thus avoiding mistakes on the part of the vessels' crew or engine-room staff, which once led to an accident at the Manchester Ship Canal.

The water supply for lockages was so exhaustively treated by the minority of the board that it has not been called into question by any one who has carefully considered the report and data submitted therewith. Recently, however, the theory has been advanced that the water of the lake may seep through the adjacent hills or through the bottom, and is significantly referred to as a mooted question. This possibility is emphasized by the seamy quality of the rock when exposed. The French plans, with Bohio Lake, were the result of careful and protracted study and investigation, and nothing of the kind was anticipated. The commission of 1901 was not in doubt of the resisting power of the hill covering such a flow. The report of the geologist on the general formation of the country does not lead to any such dread or fear. The reservoirs, constructed in the hills of the same geological formation as the entire lake area, are not affected by any such leakage or seepage. At Black Swamp, an extensive area between Bohio and Gatun, the water stands above the level of the Chagres—which is within half a mile—and also above sea level the level of the water remains unchanged, clearly indicating no such leakage.

The estimated cost by the present commission for completing the adopted project, excluding the items left out by the Board of Consulting Engineers, is placed at $297,766,000. If to do this be added the estimated cost of sanitation and civil government until the completion of the work, and the $50,000,000 purchase price, the total cost to the United States of the lock type of canal will amount to $375,201,000. In the preparation of these estimates there are no unknown factors.

The estimated cost of the sea-level canal for construction alone sums up to $477,601,000, and if to this be added the cost of sanitation and civil government up to the time of the completion of the canal, which will be at least six years later than the lock canal, and the purchase price, the total cost to the United States will aggregate $563,000,000. In this case, however, parts of the estimate are more or less conjectural—such as the cost of diverting the Chagres to permit the building of the Gamboa dam and the cost of constructing the dam itself.

Much has been said of the disadvantage of the seamy rock in connection with some experiments made at Spillway Hill test pit and of the so-called "indurated clay," yet these same disadvantages apply to the foundation at Gamboa and the same class of material must be dealt with. The cost of constructing and maintaining a channel through the swamps of the lower Chagres is an unknown factor, and no schemes have been developed for controlling the various streams that are encountered and that must be reckoned with along the route of the canal. So that the sea-level estimates have not the accuracy of those for the lock type.

The majority of the Board of Consulting Engineers estimated that from 10 to 13 years would be required for the completion of the sea-level canal. The Isthmian Canal Commission and the then Chief Engineer fixed the time from 18 to 20 years. It will take at least 6 years to complete the dam at Gamboa, and until the control of the Chagres River is assured, little if any excavation can be carried lower than 40 to 50 ft. above sea level, so that in the absence of anything more definite, the time needed to construct the Gamboa dam is assumed as the additional period needed for completing the sea-level type.

Much criticism has resulted because of the excess of the present estimates over those presented by the Board of Consulting Engineers in 1906, arising largely from a failure to analyze the two estimates, or to appreciate fully the actual conditions.

The estimates prepared and accompanying the report of the consulting engineers were based on data less complete than are available at present. The unit costs in the report of 1906 are identical with those in the report of 1901, and since 1906 there has been an increase in the wage scale and in the cost of material. On the Isthmus, wages exceed those in the United States from 40 to 80% for the same class of labor. The original estimates were based on a ten-hour day, but Congress imposed the eight-hour day. Subsequent surveys and the various changes already noted have increased the quantity of work by 50%, whereas the unit costs have increased only 20%—not such a bad showing. In addition, municipal improvements in Panama and Colon, advances to the Panama Railroad and moneys received and deposited to the credit of miscellaneous receipts aggregate $15,000,000, which amount will eventually and has in part already returned to the Treasury. Finally, no such system of housing and caring for employees was ever contemplated as has been introduced and installed, materially increasing the overhead charges and administration.

Much stress has been laid upon claims that recent improvements in machinery have so modified [illegible]tions that the excavation can be done more economi[illegible]y special devices in conjunction with dredging th[illegible] possible with the methods now adopted. The ma[illegible] referred to are for shattering rock under water, a[illegible]gh it is claimed that such devices have given satis[illegible]y results in connection with the Manchester Shi[illegible]al, it is known that similar appliances have fa[illegible] certain localities in the United States where th[illegible]re tried. The variations in the character of the roc[illegible] the Isthmus, from soft argillaceous sandstone to [illegible] trap, are such as to make the use of such devices v[illegible]oblematical. Experience generally has shown tha[illegible]e money can be wasted on subaqueous rock excav[illegible] than in the removal of such material in the dry. [illegible]eriments are now being made on the Isthmus with [illegible] of these rock-crushing devices, but thus far the r[illegible] are not promising.

Much has been written recently concerni[illegible] the probable effect of earthquakes. The last earthq[illegible]e of any importance occurred in the seventeenth centu[illegible] and existing ruins in Panama demonstrate clearly that no shock of any violence could have occurred during the eighteenth or nineteenth centuries. Should an earthquake visit the Isthmus, the chances are that the effect upon the Gatun dam would be less disastrous than upon the Gamboa dam. The solid concrete construction of the locks, strengthened by reinforcements, will be as proof against any earth shocks as any structure which man builds anywhere, and the sea-level canal has as much to fear as the lock canal.

The vulnerability of the lock canal in time of war is another argument advanced in favor of the sea-level type, but has little weight, as the sea-level type is equally vulnerable from attacks by land or air in its Gamboa dam and in its tidal locks and the various devices for controlling the streams along the route.

The idea of the sea-level canal appeals to the popular mind, which pictures an open ditch offering free and unobstructed navigation from sea to sea, but no such substitute is offered for the present lock canal. As between the sea-level and the lock canal, the latter can be constructed in less time, at less cost, will give easier and safer navigation, and in addition secure such a control of the Chagres River as to make a friend and aid of what remains an enemy and menace in the sea-level type.

We are justly proud of the organization for the prosecution of the work. The force originally organized by Mr. John F. Stevens for the attack upon the continental divide has been modified and enlarged as the necessities of the situation required, until at the present time it approaches the perfection of a huge machine, and all are working together to a common end. The manner in which the work is being done and the spirit of enthusiasm that is manifested by all forcibly strikes every one who visits the works.

I have endeavored to show that a channel of sufficient width, in which the waters of the many streams, especially the Chagres, will not be a menace, is one most desired for an Isthmian canal. The sea-level canal proposed by the majority of the Board of Consulting Engineers is not of sufficient width, nor is the proposed solution for the impounding and diversion of the Chagres and other streams based upon sufficient investigations to insure its success. The "ideal" sea-level canal, the Straits of Panama, recently proposed, is not based upon any investigations of the work to be done and cannot, in view of the approximate estimate of the cost of our own sea-level canal, which is about one-third the size of the "ideal" plan, be given serious consideration. Every criticism against the stability of our locks or dams can be attributed to either an argument in favor of one's own plans or to absolute ignorance of the exhaustive data concerning their safety now in existence. The several other plans of lock-type canal have nothing in their favor that the plan now adopted does not possess to a greater degree.

I cannot do better than quote from the message recently sent to the Congress, "that hereafter attack on this type—the lock type—is in reality merely attack upon the policy of building any canal at all," for the adoption of a sea-level canal anywhere approaching the ease of navigation of the lock type will result in the ultimate abandonment of the canal. I assure you that several years hence, no later than Jan. 1, 1915, even the most ardent sea-level advocates will, in making the voyage through the canal, admit that the ability to safely navigate a battleship at a high rate of speed through the lake and wide channel from Gatun to Pedro Miguel far outweighs the small inconveniences of the lockages up to and down from the summit level.

THE GERMAN SHIP "MARGRETHA," of 2,060 tons burden, sank March 14 about 20 miles west of the Maas Lightship off the coast of the Netherlands shortly after a collision with the Norwegian steamer "Mascot." Of the "Margretha's" crew of 26, 20 were drowned. The "Mascot's" bow was seriously damaged but she was able to return to port at Rotterdam. The "Margretha" was bound for Hamburg, Germany, from Iquique, Chile.

A SEWER CAVE-IN AT HAMILTON, OHIO, March 11, buried three men at the bottom of the trench, which was about 12 ft. deep. Two of the men died before they could be dug out, while the third was rescued but is not expected to live.

A POWDER MILL EXPLOSION at the Rand Powder Co.'s plant at Marlow, Tenn., March 8, killed two men and injured three others. The explosion occurred in the corning mill.

AN OPEN-HEARTH FURNACE ACCIDENT at the plant of the American Steel & Wire Co. at Cleveland, Ohio, March 12, fatally injured three men and less seriously injured as many others. Reports state that the accident was caused by a leak in the furnace wall. Molten metal escaping through the wall, dropped into a water vat beneath the furnace. An explosion resulted which destroyed the bottom of the furnace and scattered the fluid steel among the 60 men at work.

A COLLISION on the Lehigh & Hudson River Ry., near Newton, N. J., March 13, between a drill engine and some runaway cars loaded with ore, killed three trainmen.

The boiler of Canadian Pacific Ry. locomotive No. 1381 exploded March 8 at the water tank near Farron Station, just west of Nelson, B. C. The brakeman and fireman were fatally injured.

A southbound express train on the Arkansas, Louisiana & Gulf Ry. was derailed March 10 about 20 miles north of Monroe, La. The engineer was killed and the fireman injured. Reports state that a switch had been thrown and spiked while the switch light was turned so as to show white.

THE FULTON STREET HUDSON RIVER TUNNEL between New York and Jersey City was holed through on March 11. The junction was made near the New York shore; both headings were in rock, the shields being left some distance to the rear. This is the last of the river tunnels at New York City to be brought to a junction. It is the fourth of the Hudson & Manhattan Ry. tunnels, its companion tube of the Lower Hudson Tunnels, the Cortlandt Street tunnel, having celebrated its meeting of headings on Jan. 27, 1909 (see Eng. News, Feb. 4, 1909, p. 127).

A LARGE DREDGE SANK in 30 ft. of water March 4 in the Monona-Harrison county ditch east of Blencoe, Iowa. The accident is ascribed to the overloading of one of the booms which extend out 70 ft. on each side to support the bucket conveyors. The dredge has an endless chain of 66 excavating buckets each carrying ½-cu. yd. of material excavated. When running at full capacity this chain makes a complete circuit in one minute and its rated capacity is 15,000 cu. yds. in 24 hrs. The water is 6 ft. deep over the sunken dredge, which is described as a three-story affair. Dikes are being erected across the ditch at each end of the dredge so that the water can be pumped out and the dredge floated. The dredge is owned by the Faris-Kesel Construction Co., of Boise, Idaho.

A BOILER EXPLOSION at the ice houses of the American Ice Co., at Farmingdale, Me., March 15, killed two men and seriously injured one other. The boiler was used to furnish steam for a 45-HP. engine driving the ice-cake conveyor. At the coroner's inquest, it was stated that the boiler was 30 years old and had been through a fire.

THE LARGEST BATTLESHIP IN THE U. S. NAVY was laid down at the Brooklyn Navy Yard, March 9. This ship, the "Florida," is the third war-vessel to be built by the government at this navy yard. The first, the old "Maine," which was blown up at Havana in 1898, was completed in 1892, and the second, the "Connecticut," which acted as flagship in the recent world-circling cruise, was completed in 1904. The "Florida" is one of the new big-gun type recently authorized by Congress. She is to be 520 ft. long, with a 70-ft. beam and will carry ten 12-in. and sixteen 5-in. guns in her heavy batteries, in addition to her lighter armament. She will register 21,825 tons. Turbines, to develop a speed of 21 knots, will be the motive power.

TENEMENTS FOR FAMILIES and individuals suffering from tuberculosis are to be built in New York City, at an expense of $1,000,000. This sum of money has been provided by Mrs. William K. Vanderbilt as an investment, and entrusted to the tuberculosis clinic of the Presbyterian Hospital. The tenements will be under the particular direction of Dr. Henry L. Shively, head of the clinic mentioned, and will be known as the Shively Sanitary Tenements. Four six-story buildings, with apartments for some 350 families, will be located on 18 city lots extending between Avenues A and B, with 225 ft. frontage on 78th St. Plans for the tenements have been made by Mr. Henry A. Smith, an architect of 1181 Broadway, New York.

A SHORTER CABLE TO ENGLAND is planned by the Commercial Cable Co., of New York. It is proposed to cut one of this company's five transatlantic cables at The Flemish Cap, 590 miles east of Newfoundland, and to attach to the European end a new cable running to St. Johns, Newfoundland, and thence to New York City. It is expected that this redivision of the line between New York and Ireland will increase the speed of transmission by 35%. This change has been made possible by the expiration of the exclusive rights of the Anglo-American Cable Co., to land cable in Newfoundland. Some 1,700 miles of new cable will be laid if this plan is carried out and the 900 miles between the Flemish Cap and Canso, Canada, will be recovered and resheathed for use elsewhere.

THE STABILITY OF ARCHES in EARTHQUAKE countries is apparently not so assured as Mr. H. G. Granger maintained in his letter on the Panama Canal in our issue of last week, p. 277, if one is to believe the following extract from the letter of the Messina correspondent to the London "Daily Mail," regarding the rebuilding of that earthquake-stricken community. The letter says

Arches have been prohibited, it being obvious that an arch presents the greatest possibilities of collapse from horizontal shakings.

NEW YORK'S PUBLIC COMFORT PROBLEM now has a solution, offered to the Aldermen in the following letter, published in the official "City Record," Mar. 11:

Petitions and Communications. No 1838.

Petition for Hire the all the Lavatories from the City New York for $30,000 for Ten years—
To the next meeting of the Board of Aldermen of the New York City:

I the Constantinos Theemaras or Dimaras and Company of Boston Mass willing to pay to the City of New York $30,000 for Ten years on the cound of each Month pay advance with that condition any person wish to use the lavatory must pay one cent to three, and sell cigars, newspaper, fruit, candies and make shoes shanes. Father more we willing pay the employees to kept, clean the lavatories, and, another condition, we willing to be get a contract to Building more Lavatories ane plase are necessary.

Boston Mass 4 March 1909.

CONSTANTINOS THEEMARAS OR DIMARAS,
46 Curve St Boston Mass.

This was referred to the Committee on Public Health.

THE BATTLESHIP WITHOUT FUNNELS, reported in our issue of last week, seems to be the product of a correspondent's imagination rather than of a British shipyard. The London "Army and Navy Gazette" corrects the first cabled reports of this boat, the "Indefatigable," as follows:

She is the biggest cruiser the world has yet seen, but she is not to be fitted with the gas-producer engine and she will have funnels and tripod masts like her elder sisters. The gas-producer engine will come, but there are several difficulties to be surmounted before that happens. Experiments are being made with trial plant at Haslar and elsewhere. Note has been taken, too, of the work done in the "Rattler," but so far no results have been sufficient to justify the application of the system to a vessel of the size of the "Indefatigable."

THE FRUHLING DREDGE, whose purchase by the Canadian Government for use on the Fraser River, British Columbia, was noted in Engineering News, Dec. 3, 1908, arrived at Victoria, B. C., March 2. Instead of crossing the Atlantic and rounding Cape Horn the route was changed so that the boat went from Kiel, Germany on Oct. 27, to Algiers and thence to Japan and across the Pacific. It is reported that the dredge encountered a succession of gales some of which flooded the crew's quarters in spite of a temporary turtle back which had been built over the open waist.

THE CONTRACTS FOR OAKLAND TERMINAL changes to allow electric traction on the suburban lines have been published by the Southern Pacific Co. These contracts were placed with Eastern manufacturers late in 1907 and amount to $748,960. The General Electric Co., of Schenectady, N. Y., will furnish 44 multiple-unit, four-motor cars for $374,960. The Westinghouse Machine Co., of Pittsburgh, will furnish two 5,000-KW. turbine generating sets for $190,000. The Parker Boiler Co., of Philadelphia, are under contract to furnish 12, 645-HP. watertube boilers at a cost of $137,000. There will be two complete surface-condenser plants from the Henry R. Worthington Co., of New York, at $47,000.

A STATE HIGHWAY from Philadelphia to Pittsburg is proposed by a bill introduced in the Pennsylvania Legislature on March 1. The road would be located under the direction of the Governor, Attorney-General and Commissioner of Highways, and after being located it would be constructed, or existing highways improved, by the Commissioner of Highways. After construction the road would be maintained by the state. An appropriation of $5,000,000 is provided, of which $3,000,000 will be available in the next two fiscal years, and $1,000,000 each in the two following years. The act does not apply to connecting links within municipalities.

THE SAN FRANCISCO WATER-SUPPLY LEGISLATION before the Congress of the United States has gone over to the next session, owing to the failure of the Senate committee to report the bill already favorably reported by the House. This bill provided for an exchange between the city of San Francisco and the United States, of lands in the Hetch-Hetchy Valley on the Tuolumne drainage area in California, and also made the permanent right-of-way permit through the Yosemite National Reservation already granted by Secretary Garfield. There is nothing to prevent the city from going ahead under the Garfield permit, and it is understood that the San Francisco Board of Supervisors has already taken steps to have plans proposed for a dam to raise the level of Lake Eleanor, a natural body of water on a stream which discharges into the Tuolumne below the proposed Hetch-Hetchy dam site. A bill is before the California Legislature authorizing municipalities to condemn for public use property in the hands of private companies which is already devoted to the public service. This legislation, together with a further proposition giving municipalities six months instead of 30 days in which to pay for property taken under condemnation proceedings, is designed to facilitate the purchase by San Francisco of the property of the Spring Valley Water Co.

ELECTRICAL OPERATION OF THE ST. CLAIR TUNNEL.—The installation of electric traction in the St. Clair Tunnel of the Grand Trunk Ry., between Sarnia, Ontario, and Port Huron, Mich., was noted in Engineering News, Nov. 19, 1908. Some figures of early operation have now been given by Mr. H. L. Kirker, of The Westinghouse Electric & Mfg. Co., in comparison with steam operation. For convenience these have been tabulated below, as taken from the "Electrical Review and Western Electrician" of March 6:

	Electric Operation.	Steam Operation.
Maximum Train Weight	1,000 tons.	700 tons.
Speed on 2% Grade	10 mi. per hr.	3 mi. per hr.
Run. Time, Summit to Summit.	10 min.	15 min.
Average Cars per Train.	27.3	19.7.
Cost of Fuel, Av. of 6 mos.	$1,152.60 per mo.	$4,956 per mo.
Coal Used	Bituminous, $2	Anthracite, $6.
Locomotive Maintenance Cost.	4.3 cts. per mi.	13.6 c. per mi.

CHANGE OF ROUTE OF THE LOETSCHBERG TUNNEL is now assured. The Swiss Department of Railways having referred the matter to the Federal Council with its approval, the Council has thereupon taken preliminary action on the matter. Several alternative routes were submitted, and the final decision will await a choice of most favorable route. However, the change has been authorized for that part of the relocated line on which the alternative routes coincide, so that in substance a change of location is approved.

The accident which makes the change necessary was a break-in which occurred on July 24, 1908, at the face of the north heading, which was then 8,774 ft. from the north portal. The tunnel here passed under a kettle-like part of the upper valley of the Kander River, and, though nearly 600 ft. below the river, it evidently had entered a depression in the rock filled by alluvial deposits—mainly fine sand. The last blast doubtless broke through the rock into this sand; at any rate, water and sand rushed in with such force that in a few minutes it filled the tunnel bore completely full for nearly a mile. Nearly the whole blasting gang was killed. Since then, the tunnel has been walled off at a point about 4,600 ft. from the portal. Expert investigations have been made to determine the best plan of procedure, but their results have not been made public. Those in charge were in favor of deflecting the line of the tunnel so as to pass around the soft-ground pocket, utilizing as large a piece of the north heading as practicable, say ¾-mile, and all of the south heading so far driven (10,548 ft. at the end of January, 1909). The detour would make the tunnel half a mile longer, and would introduce at least three curves.

The "Schweizerische Bauzeitung" of Feb. 20 reports that heading work was started in the north end early in February, at 4,962 ft. from the portal. The new line is to turn off from the existing north heading at 3,936 ft. with a curve to the eastward.

A NEW YORK-NEW JERSEY BRIDGE REPORT was rendered to the legislatures of the two states by their respective delegations to an interstate commission which has been studying the subject. The reports recommended suitable sites for bridges. A bridge across the Hudson may be placed at 59th St., at 110th St., at 135th St. or at 179th St., New York City, but the opinion is expressed that a bridge at 59th St. would have the greatest traffic value, since it would be nearest to the centers of population on both shores. However, this would be the most costly of the four sites. No analysis of traffic